POWER

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Give Us the Facts

AT ONE of the early meetings of the American Society of Mechanical Engineers a member who prided himself upon his practicality and who was inclined to belittle the analytical processes of the scientist, remarked in debate that there was no difference between theory and practice—*if the theory was right.*

After the laughter which his sally invited had subsided, Dr. R. H. Thurston responded, "And permit me to add, Mr. President, *if the facts are correctly stated.*"

Most of the difficulty in settling the problems of the day comes from an incomplete or distorted statement of the facts.

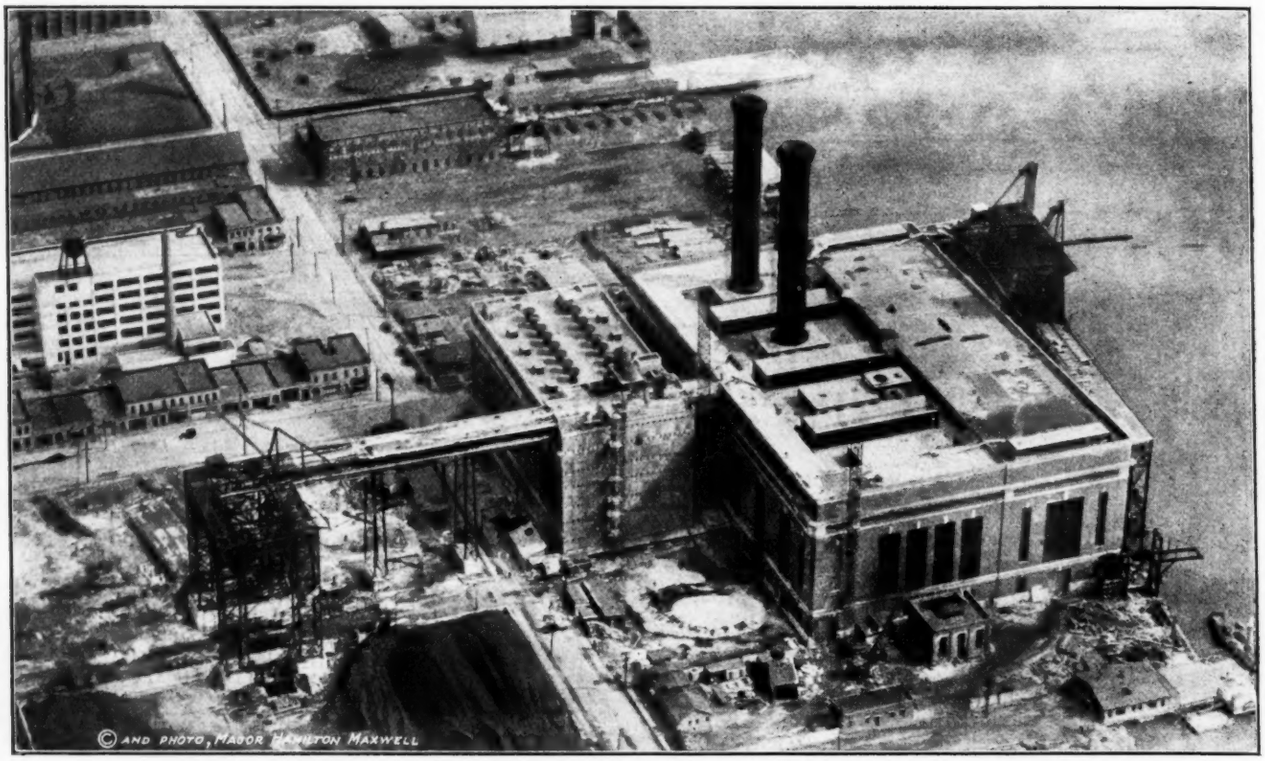
The engineer with his analytical habit of thought is particularly well able to go to the root of the problem and to indicate its solution along the lines of the greatest efficiency; but he must have the facts as the basis of his analysis. And perhaps no class of thinkers are so likely to become impatient and discouraged at the policies of secrecy and suppression, the murk of sophistry and misrepresentation by which the progress of direct thinking is hindered and the aspect of a subject is muddled.

The fuel supply of the country is eminently a matter of public interest and concern. The industrial life of the nation, the comfort and physical well-being of the people, depend upon it. An abundant, cheap and dependable fuel supply is as essential to the life of the nation as food and water to the individual. Just as a growing community casts about for an adequate water supply, studying the accessible watershed and the rainfall and sources of pollution and systems of purification and distribution, reducing it all to a comprehensive interrelated system in which the best use is made of the available resources and the best service rendered to all with the least expenditure, so the nation should survey and analyze and correlate and conserve its greatest natural resource, its fuel supply. But in order to do this, the Government must have the facts, and to their everlasting discredit the coal producers refuse to give them, and defeated legislation designed to make them accessible.

A great strike is going on which affects, directly or indirectly, every inhabitant of this country. What does the public know about it? What are the real points at issue, and what are the facts in the case?

After all, the basic question is what becomes of the money that you pay for a ton of coal delivered to your siding or your cellar? How much of it goes to productive labor, how much to salaries of actually necessary officials, how much to interest on actually invested capital, how much to royalties and to unnecessary reselling, how much to profit. Let the purchasing public know this, and they will soon make up their minds whether they are getting what they pay for from the operators or the miners or the railroads and other distributors or all or any of them. And when they know whether they are being bilked by organized labor or organized trade or neither or both, all the collateral quarrels will fade away before the force of an enlightened public opinion like a mist before the sun.

F. R. Low



New Hell Gate Power Station*

The United Electric Light and Power Company

THE new Hell Gate Power Station of The United Electric Light and Power Co. is between 132d and 134th Sts., New York City, on the Bronx shore of the East River and not far above the Hell Gate Bridge. This location meets the fundamental requirements of a good central-station site with regard to circulating water, fuel supply, nearness to center of load and price of land. The East River provides a supply of relatively cool sea water for the condensers. Coal may be brought directly to the plant in scows or barges, while a rail connection serves as an auxiliary source of supply. The southeastern part of the Bronx, in which the plant is situated, is considerably south of the northern tip of Manhattan Island, so that the plant is close to the center of load. At the same time realty values are lower than those found in any otherwise-suitable location in Manhattan.

The ultimate capacity of the Hell Gate Station will be 300,000 kw., produced by eight turbine units. Steam will be furnished by twenty-four boilers. At present four of these turbines (see Fig. 2) and twelve boilers are installed and in operation. The units are arranged in independent groups, each of which contains two turbines (one of 35,000 kw. and one of 40,000 kw.), one house turbine and six boilers served by one stack.

As the station is interconnected with other plants serving Greater New York, and is intended to operate on a base load, the character of the demand placed no limitation on the size of boilers and generating units. The sizes chosen were those considered most desirable from the viewpoint of the operating man and, at the same time, large enough to insure substantially the best obtainable output per pound of coal. In selecting the units, as in all other matters pertaining to the design of this plant, the all-important consideration was continuity of service. The next consideration was low total cost per kilowatt-hour.

The group system practically divides the station into four distinct power plants (two in the present installation) each of 75,000-kw. capacity. This arrangement has a number of advantages. It simplifies the layout, particularly the piping. General control and the regulation of

ON February 2, 1921, work was started on the superstructure of the new 300,000-kw. Hell Gate Power Station in New York City. Nine and one-half months later power production began. The present installation contains four main turbines, two of 40,000 kw. and two of 35,000 kw. Steam at 250 lb. and 200 deg. superheat is furnished by twelve 18,900-sq.ft. boilers, double-fired with underfeed stokers. The ultimate plant will contain twenty-four boilers and eight main turbines arranged in four independent groups. Coal is handled between barges, bunkers and storage by movable coal towers and cable roads. Ashes are removed by a simple system of hydraulic sluicing. With a few exceptions all the auxiliaries are motor-driven.

*Supplementing the present article, a large insert (32 in. x 22 in.), showing a typical cross-section of the Hell Gate station, accompanies this issue.

the heat balance are made easier. Troubles in one group do not affect another, but such elements of the various groups as forced-draft air supply, feed-water supply, steam supply, etc., may be interconnected at will. Moreover the group system makes it a simple matter to increase station capacity by adding new groups as the growth of the load requires it.

The general arrangement of the plant and coal storage is shown in Figs. 3 and 4. Space has been left in the present boiler and operating rooms for the units that will be later installed to bring the station up to its ultimate capacity of 300,000 kw. The present generating units (totaling 150,000 kw.) together with the corresponding boilers and house turbines, are shown (cross-hatched) in the northern halves of these rooms. The units (shown without cross-hatching) in the southern halves will be installed at some future time. The only new building construction required for the ultimate plant will be in the electrical building, where an extension duplicating the present "electrical galleries" must be built in the open space south of the "control galleries."

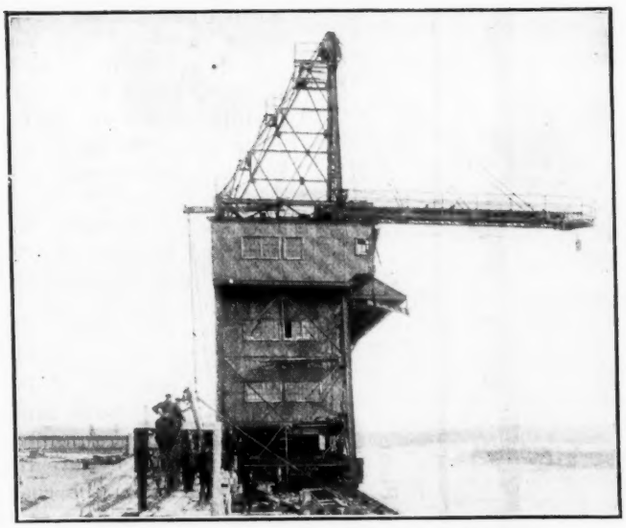


FIG. 1. ONE OF THE TWO COAL TOWERS

An unusual feature is the location of the boiler room between the turbine room and the electrical galleries, with the turbine room next to the river. This results in two apparent disadvantages. It increases the distance between the place where electrical energy is generated and the place where its distribution is controlled. At the same time it increases the distance the coal must be carried in going from the barges to the bunkers. The importance of the electrical separation is minimized by careful design and construction of the electrical system. The additional coal-handling expense due to 200-ft. additional horizontal travel in the cable cars is only a small fraction of the total coal-handling expense. The offsetting advantage of the arrangement adopted is the great saving in the cost of handling cooling water from the river to the condensers and back. This saving consists partly in reduced power for pumping and partly in a reduction of fixed charges due to the fact that a large amount of tunneling through solid rock is avoided. The circulating water used, when all eight units are in operation, will amount to

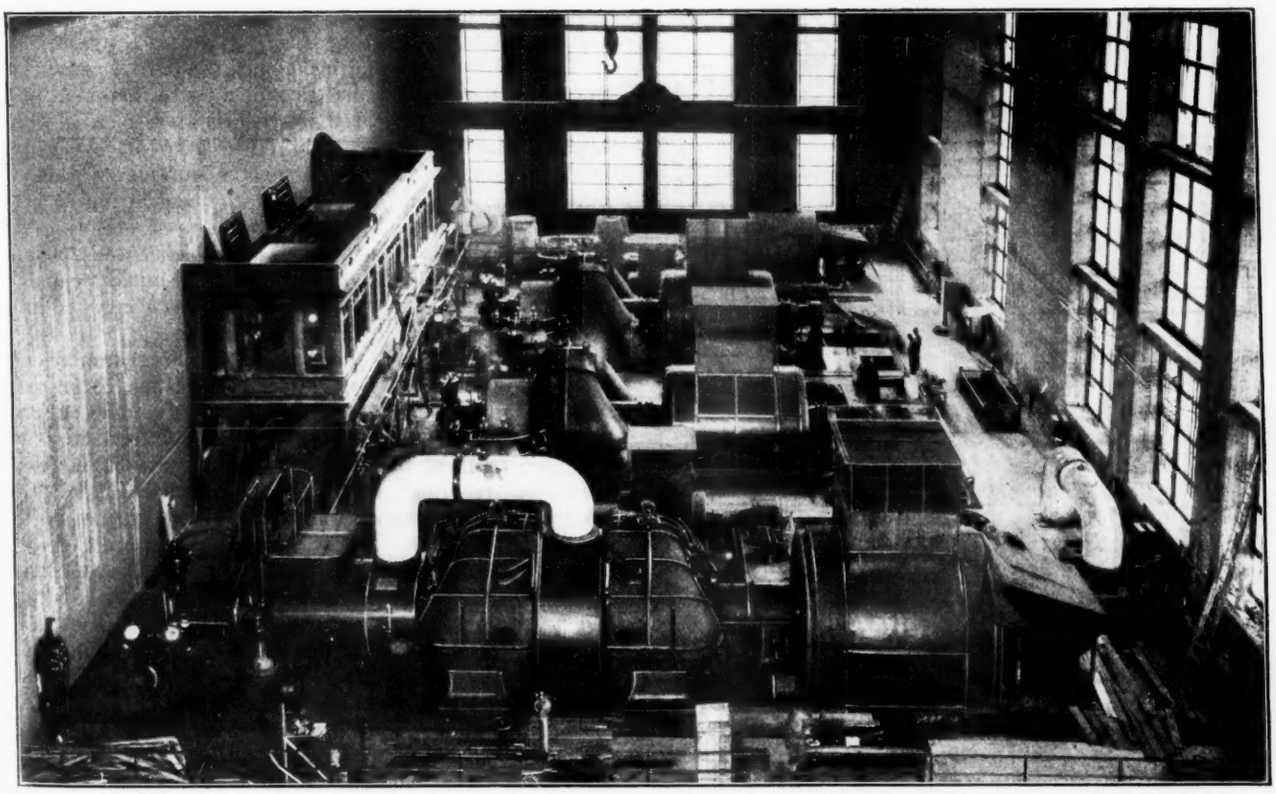


FIG. 2. NORTHERN HALF OF OPERATING ROOM, SHOWING ALL GENERATING UNITS IN PRESENT INSTALLATION

The main units are numbered consecutively, starting at the far (north) end. No. 1 and No. 4 are the 40,000-kw. tandem-compound, 60-cycle units while No. 2 and No. 3 are the 35,000-kw., 25-cycle units. No. 1 and No. 2 form the first group, while No. 3 and No. 4 form the second. Each group has its own house turbine (2,000 kw.), located between the two main units. The switching gallery at the left is used only for house-turbine and heat-balance control. The main electrical control is in another building.

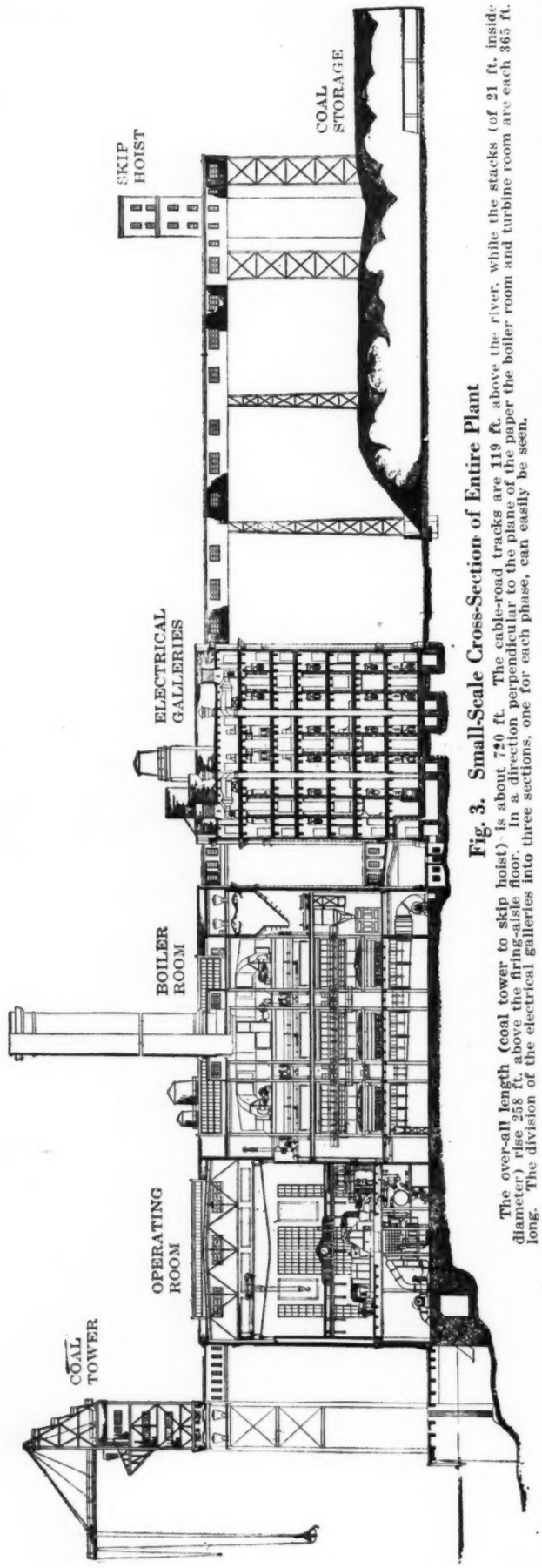


Fig. 3. Small-Scale Cross-Section of Entire Plant

The over-all length (coal tower to skip hoist) is about 720 ft. The cable-road tracks are 119 ft. above the river, while the stacks (of 21 ft. inside diameter) rise 258 ft. above the firing-aisle floor. In a direction perpendicular to the plane of the paper the boiler room and turbine room are each 365 ft. long. The division of the electrical galleries into three sections, one for each phase, can easily be seen.

800,000,000 gal. per day, 60 per cent more than the total water supply of New York City.

Considering first the coal-handling system, as shown in Figs. 3 and 4, it will be noticed that the boiler and turbine rooms are encircled by an inner and an outer cable road, the latter having an extension reaching to the two coal-storage areas. The track level of these cable roads is 119 ft. above the surface of the river. The section of cable road facing the water front is straddled by two traveling coal towers. Fig. 1 shows one of these. By means of tracks above the cable-road level, the towers have a combined travel of 216 ft. along the river front. Each tower has a 2-ton bucket which lifts the coal from the barge to a crusher in the tower. From this it is fed directly to cable cars on either track. Both inner and outer cable roads pass over the bunkers located along the west side of the boiler room, but only the former is normally used to carry coal from the coal towers to the bunkers. The outer cable road serves to carry coal from the towers to the storage areas and from the latter to the bunkers. Each coal tower and each cable road has a capacity of 250 tons per hour.

The loaded cars are automatically weighed while moving over a certain section of track, the net weights being printed on a roll of paper. By setting the dumping lever over any bin, each cable car is automatically dumped as it passes that point.

The movement of coal from the cable-road extension to the storage piles and vice versa is accomplished by means of the chutes, drag scrapers and skip hoists shown in Fig. 4. Coal may also be transferred to the southern storage area, from railroad cars on the 132d St. siding, by means of locomotive cranes and drag scrapers. The outdoor storage capacity is approximately 100,000 tons.

The bunkers, extending along the entire west side of the boiler house, are provided with gates at nine points. Coal is delivered by these gates to nine weigh larries running toward the river between every two rows of boilers, as well as on the outside of the two outer rows. From these larries, the coal is fed directly to the stoker hoppers of the double-fired boilers. The bunkers hold 400 tons for each double aisle and 250 tons each for the single aisles, giving a total bunker capacity of 3,300 tons. The double-aisle larries carry 25 tons each and the single-aisle larries 15 tons.

The method of ash removal, shown diagrammatically in Fig. 5, is remarkably simple. The ashes, after passing through the double-roll clinker grinders at the bottom of the furnaces, fall into an inclined concrete, tile-lined trough, through which a stream of water is constantly flowing. A trough of this sort under each row of boilers empties into a common discharge tile trough, which carries the water and ashes into concrete-lined pits on the waterfront just south of the southeast corner of the turbine room. The ashes are there stored under water, awaiting removal by the 2¼-yd., perforated clamshell bucket of a gantry crane. This dumps the ashes directly into a barge or motor truck. The ash-pits and gantry crane are also shown in Fig. 4.

The ultimate capacity of this ash-sluicing system will be 25 tons an hour, water being supplied by six (three now installed) 5,000-gal.-per-min., centrifugal pumps driven by 125-hp., 2,200-volt squirrel-cage motors. While the water is delivered to the troughs by nozzles at each boiler (pointed downstream in order to boost the flow), main dependence for the flow of ash and

water is placed on the trough's pitch of ¼ in. per foot.

The boilers are of the Springfield, cross-drum, sectional water-tube type and will normally operate at 250 lb. pressure. Elseco superheaters are installed. At 200 per cent of rating the superheat obtained is 200 deg. F., giving a total temperature of 607 deg. F. The pressure and superheat were selected on the same basis as the size of the turbines, with continuity of service as the first consideration.

Each boiler contains 18,900 sq.ft. of water-heating surface and 2,135 sq.ft. of superheating surface. The boiler tubes (3 in. x 20 ft.) are arranged 54 wide and 20 high. Careful consideration was given to the question of using lower boilers with economizers, but it was decided that the present price of coal did not warrant the use of economizers in this plant. Space was left for their installation if it should become desirable.

Each boiler is fired from both sides by means of two, 14-retort, underfeed Taylor stokers, driven by constant-speed motors through a variable-speed transmission. This gives the stoker rams a speed variation from one-quarter stroke to one stroke per minute. The corresponding rates of firing are 3½ and 14 tons of coal per hour per boiler.

The combustion volume per boiler is about 8,000 cu.ft., or 0.42 cu.ft. per square foot of water-heating surface. Assuming a 13,000-B.t.u. coal and 75 per cent boiler efficiency, this amounts to 1.23 cu.ft. per pound of coal burned per hour at rated capacity. The lowest tubes are 16 ft. from the floor at the low end and 21 ft. at the other. In the plan view the inside of the furnace is 18 ft. by 25 ft., the former dimension being parallel with the tubes and perpendicular to the firing aisles.

Each group of six boilers has a single stack and breeching, the latter running east and west with three boilers on each side. Just below the breeching are six cinder-catching compartments similar in appearance to the breeching proper. In each of these the gases rising from the uptake are sharply deflected by a baffle, so that the cinders are thrown into a tank of water. The flue gases are drawn from each cinder-catching section and delivered to the breeching by an individual induced-draft fan driven by a brush-shifting motor. Dampers are provided, however, for bypassing these fans.

The stack, which joins the breeching directly at its center, is of steel, brick-lined and supported on the steelwork of the building. It rises 258 ft. above the firing aisle and has an internal diameter of 21 feet.

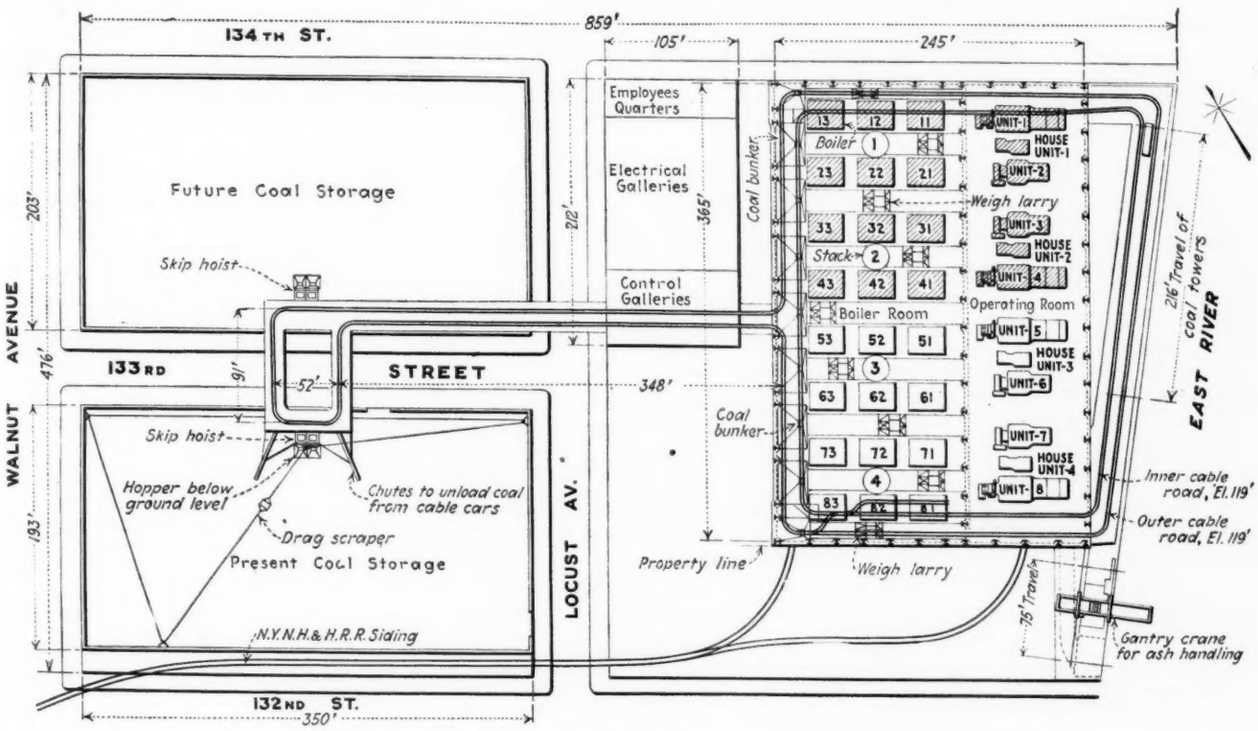


FIG. 4. PLAN OF ENTIRE PLANT SHOWING OUTLINE OF STRUCTURES, COAL-HANDLING SYSTEM, BOILERS AND TURBINES

The buildings and other structures are complete for 300,000 kw. except that duplicate electrical galleries must be built. Boilers and turbines for a capacity of 300,000 kw. are shown, but the present installation (150,000 kw.) is indicated by cross hatching.

Forced-draft ducts run along both sides of each row of three boilers. Each of these ducts branches out of a single large duct running the whole length of the boiler house on the west side. This main duct, however, is provided with dampers to shut off any row of boilers. Four fans, driven by brush-shifting motors, supply air for each group.

The furnace pressure is controlled by a balanced-draft equipment so arranged that, when the induced-draft fans are placed in operation, their speed is automatically regulated in relation to furnace pressure. This and other boiler-room equipment will be described more fully in the May 9 issue of *Power*.

As previously stated, the Hell Gate Station will ultimately have eight large turbo-generators with a total capacity of 300,000 kw. and four house turbines, one for each group of two large turbines. The present installation comprises two groups totaling 150,000 kw.

One of the main units in each group of the present

installation is a 35,000-kw. 25-cycle, General Electric, Curtis-type, horizontal, single-cylinder turbine running at 1,500 r.p.m. The steam, entering with 250 lb. pressure and 200 deg. superheat passes through 20 Curtis, single-row, impulse stages to an absolute pressure around 1 in. The guaranteed water rate is as follows:

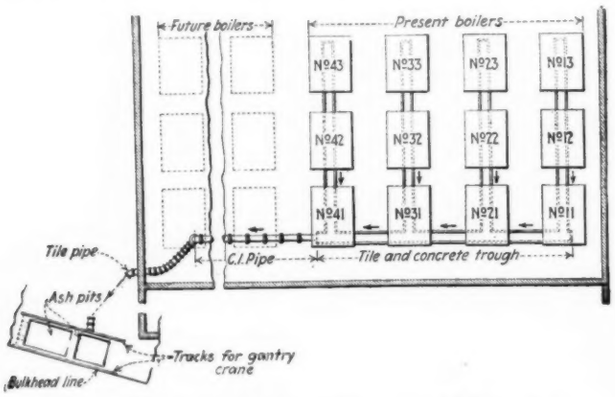


FIG. 5. DIAGRAMMATIC SKETCH OF HYDRAULIC ASH-REMOVAL SYSTEM

Kw. Output	Pounds Steam Per Kw.-Hr.
20,000	10.85
27,500	10.30
35,000	10.65

The 11,400-volt 25-cycle three-phase Y-connected generator has a maximum ventilation of 65,000 cu.ft. of air per minute. A 95-kw. exciter is direct-connected.

The other turbine of the group is a 40,000-kw. 60-cycle Westinghouse semi-double-flow, Parsons' type, tandem machine running at 1,200 r.p.m. and operating under the same steam and vacuum conditions as the 35,000-kw. unit. The high-pressure element (single-flow) contains 45 rows of rotating and stationary blades. The single-flow element of the low-pressure end contains 15 rows of rotating and stationary blades, while each of the double-flow elements has eight rows of rotating and stationary blades. The guaranteed water rate of the 40,000-kw. unit is as follows:

Kw. Output	Pounds Steam per Kw.-Hr.
15,000	11.15
20,000	10.75
28,000	10.40
35,000	10.65
40,000	10.90

The generator on the 40-000-kw. unit is a 13,200-volt 60-cycle three-phase Y-connected machine, ventilated with 140,000 cu.ft. of air per minute. It has a direct-connected 135-kw. exciter.

The turbines are bled at two points (one at about 6 lb. absolute and the other at a little above atmospheric pressure) to provide steam for the closed heaters and emergency steam for the open heaters in case the temperature of the feed water falls below 210 degrees.

Each main unit is provided with a complete self-contained oil system consisting of pumps, filters and oil coolers. One oil pump is geared to the turbine. The emergency oil pump (also used for starting) is steam-turbine driven. A pressure-controlled valve starts this pump automatically should the geared pump fail. Water from the surge tank is used to cool the oil. The heat in this cooling water is recovered in the feed-water heating system.

There is a batch filter which may be used to filter oil from any unit. Two centrifugal filters are being installed with the General Electric units.

Although the present installation of four units comprises 70,000 kw. of 25-cycle current and 80,000 of 60-cycle, the division of the future additional 150,000 kw. between 25-cycle and 60-cycle has not been determined, as it will depend on the growth of the respective loads. The 25-cycle power goes to rotary-converter substations. The nature of this load makes possible the 100-per cent load factor on which the 35,000-kw. units are rated. The rating of 40,000 kw. for the 60-cycle units is obtained at 90 per cent load factor.

In addition to the two main units, each group contains a 2,000-kw. 2,300-volt Westinghouse 60-cycle three-phase house turbine running at 3,600 r.p.m. This has two exciters, one turbine-driven and one motor-driven.

Each main unit will exhaust to one 50,000-sq.ft. surface condenser. The Westinghouse (40,000-kw.) turbines are connected to Westinghouse condensers by means of rubber expansion joints. These are elliptical, and made of molded rubber $\frac{3}{8}$ in. thick. The ends of the joints are beaded to fit clamps on the turbine and condenser. Two exhaust outlets, each having a cross-sectional area of 105 sq.ft., provide the openings from turbine to condenser. The condenser is hung from the steelwork of the turbine foundation.

The General Electric turbines are rigidly connected to Worthington condensers, the latter being supported on springs to provide for expansion. Both condensers have 10,050 one-inch tubes of No. 18 B.w.g., Admiralty mixture, 19 ft. in active length. Each water-box is divided vertically, one motor-driven 35,000-gal.-per-min. circulating pump supplying each side. This divided water-box permits repairs and cleaning without a shutdown.

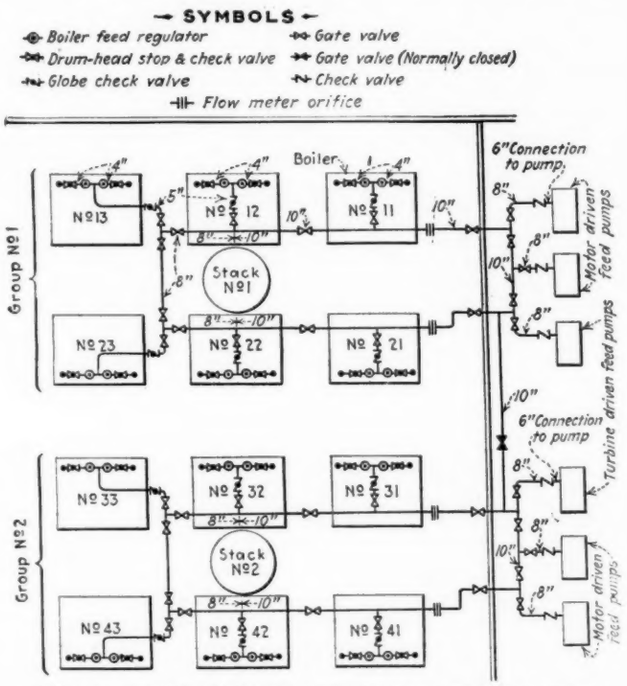


FIG. 6. DIAGRAMMATIC SKETCH OF FEED-WATER PIPING FOR TWO GROUPS

All circulating-water piping is connected to the condensers by rubber expansion joints. Salt-water leakage, which bears a direct relation to electrical conductivity, is measured by means of low-range ammeters.

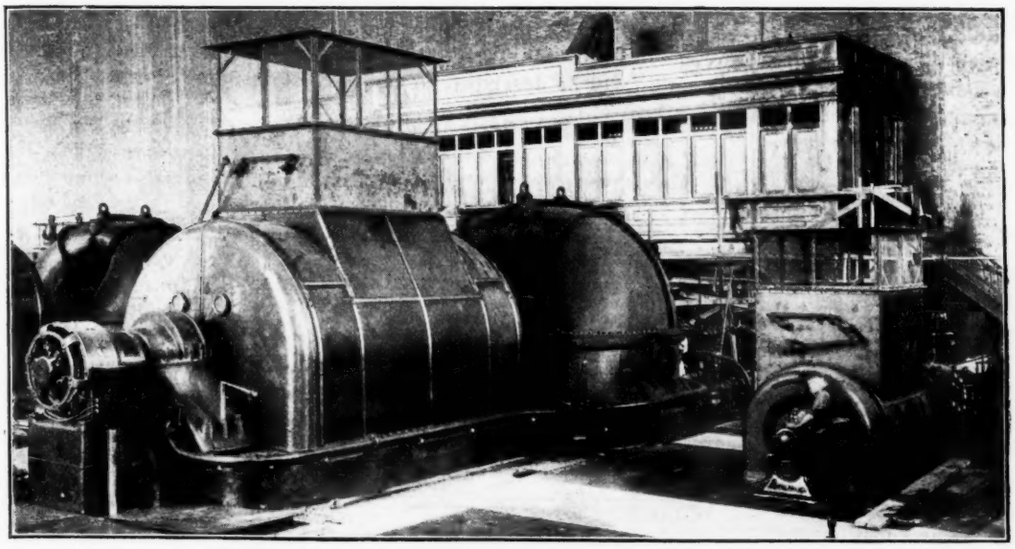


Fig. 7—View in operating room, showing 35,000-kw. turbine (No. 2 of first group), the 2,000-kw. house turbine of group 1 and the switching gallery for controlling the house turbines and heat balance. The large turbine has 20 single-row Curtis stages and runs at 1,500 r.p.m. Its generator is a three-phase 25-cycle 11,400-volt Y-connected machine. The complete unit occupies a space 46 ft. long, 20 ft. wide and 13 ft. high.

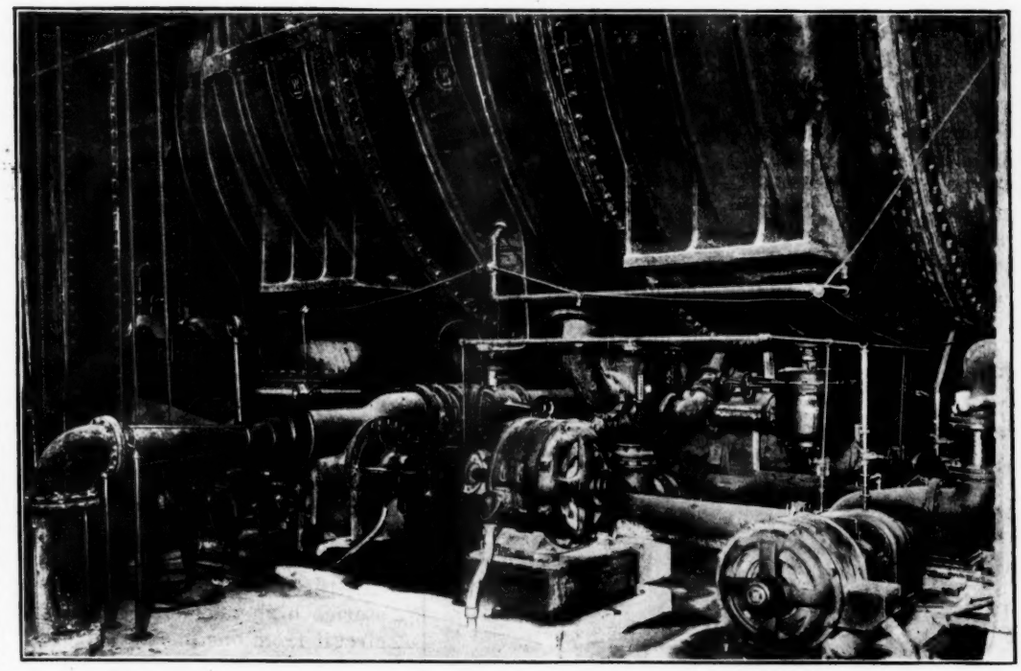


Fig. 8—The 50,000-sq.ft. condenser and auxiliaries on turbine No. 1 (40,000 kw.). The condenser is equipped with divided water-box, two sets of circulating pumps and piping so that one-half of the water-box may be opened without disturbing the other half. The top of one of the circulating pumps can be seen in the left background. At the bottom of the left end of the condenser are the two inlet connections for circulating water. In the left center is one of the hydraulic air pumps, while one of the hotwell pumps is shown on the right. These motor-driven auxiliaries are duplicated on the other side of the condenser.

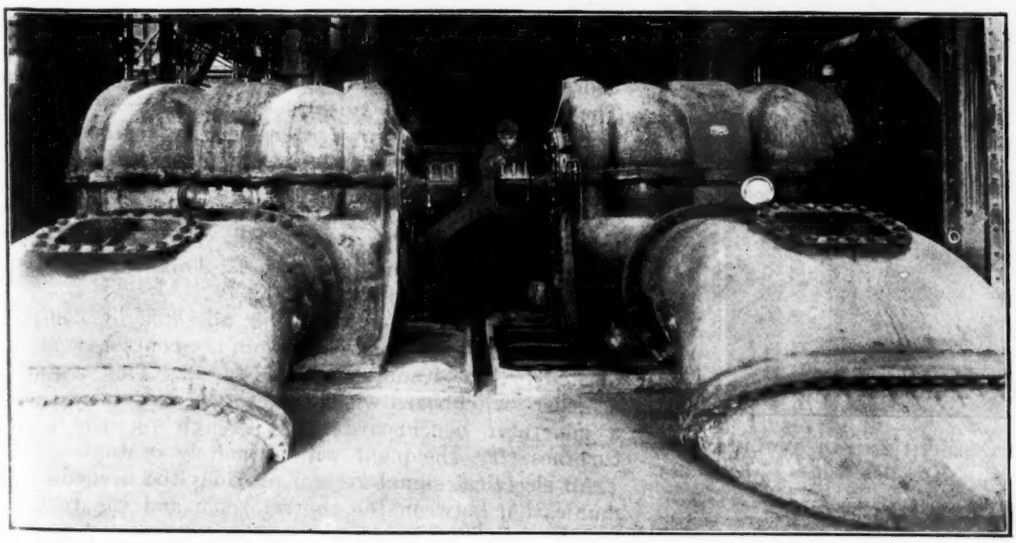


Fig. 9 — Circulating pumps for condenser on turbine No. 4 (40,000 kw.). These are the same as the pumps used with unit No. 1 (see Fig. 8, above). Each of these pumps takes 35,000 gal. of salt water per minute from the river front through an individual 54-in. pipe and delivers it to one-half of the condenser. The discharge is carried to a tunnel parallel with the river front by means of two 54-in. pipes. The circulating pumps are driven by 350-hp. motors.

Cooling water for each condenser is taken in from the East River through two 54-in. pipes and discharged through two pipes of the same size into a tunnel parallel with the river bank and having upstream and downstream discharges. Stationary bar screens are used at the inlet, the water supply being relatively free from débris and the velocity of the intake water being very low. Data on condenser air pumps, and other auxiliaries, are given in the table of principal equipment at the end of this article.

Each group has three 1,000-gal.-per-min. 4-stage centrifugal boiler-feed pumps, two motor-driven and one turbine-driven. The feed-water piping from the pumps to the boilers is shown in Fig. 6. It will be noted that the feed-water piping for any group is entirely independent except that it may be connected with the next group by opening a 10-in. valve. There are two 350,000-lb.-per-hr. closed heaters and one 1,000,000-lb.-per-hr. open heater for each group. These heaters form part of the heat-balance system.

The feed water, consisting of the condensate with a small proportion of makeup from the city mains, is heated successively by: (1) Steam bled from the main turbines at 6.5 lb. absolute pressure; (2) by the addition of hot water from the oil coolers and air-ejector condensers; (3) by the addition of condensed gland-packing steam (1 lb. gage), and (4) by the exhaust of the house turbine. Of these (1) and (4) are, of course, the main sources of heat. The feed temperature is maintained around 210 deg. by varying the auxiliary load carried by the house turbine. The switching equipment for the house turbines and also the heat-balance instruments and control are located in a gallery above the turbine floor. The system of heat balance will be described in the May 16 issue of *Power*.

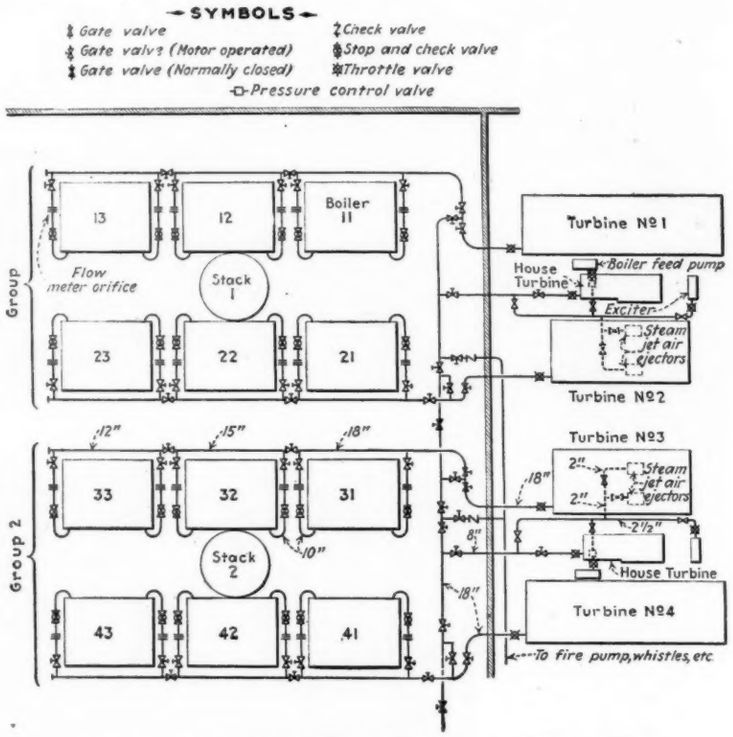


FIG. 11. DIAGRAMMATIC SKETCH OF STEAM PIPING FOR TWO GROUPS

Fig. 11 shows the layout of the steam piping. Here, as in the case of the feed piping, the groups are entirely independent, except that one group may be connected to the next by an 18-in. valve.

No attempt will be made to describe the electrical switching equipment except to call attention to features of particular interest. The switching portion of the electrical galleries is divided into three sections, for the three phases, by continuous concrete walls seven stories high. This novel arrangement makes a short-circuit from one phase to another practically impossible. Perpendicular to these are walls forming separate sections for each main unit. The oil switches, located on the second, fourth and sixth floors, are operated by solenoid mechanisms on the third, fifth and seventh floors. These cut in the three phases simultaneously. The location of the various switches is as follows: Generator and outgoing-feeder switches, second floor; bus-selector switches, fourth floor; bus-tie switches, sixth floor. The main and auxiliary buses are located on the fourth floor. The specifications for the electrical galleries provide that no two reinforcing bars in the concrete shall be in contact. This was done to avoid induced currents.

All the switching apparatus is operated by 250-volt direct-current, and controlled from the control room indicated in Fig. 4 and shown in Fig. 12. This contains a feeder switchboard with space for 96 feeders and also a generator benchboard large enough for the eight turbines that the plant will ultimately contain.

An electrical signal system provides the needed communication between the control room and the turbine

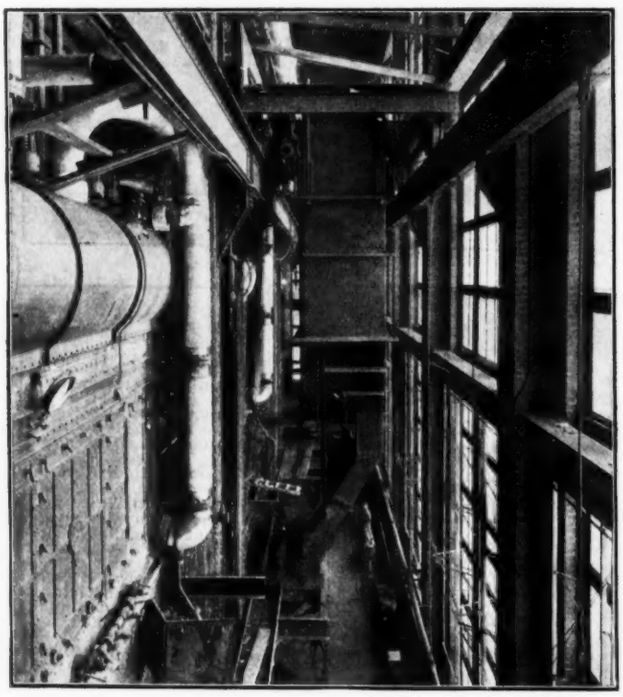


FIG. 10. FIRING AISLE AT NORTH END OF BOILER ROOM

This shows three of the twelve water-tube boilers now installed. Each boiler is double-fired by means of two 14-retort underfeed stokers and has 18,900 sq. ft. of water-heating surface. The larry shown carries 15 tons. Those in the center aisles carry 25 tons.

room, which is located in another building and not in view of the switchboard operator. It is believed that this arrangement, freeing the operator from unnecessary noise and other distractions, is superior to that ordinarily used.

It is of interest to note that all the station auxiliaries are motor-driven with the exception of one small turbine-driven exciter and one feed pump per group, as well as one fire pump for the station. One-half the power for the motor-driven auxiliaries of a given group may be obtained from the main 60-cycle bus and the other half from the house alternator, so that only one-half the auxiliaries are shut down if either source of power is interrupted.

All motors 25 hp. and over, excepting the motors on the coal towers, cranes and skip hoist, operate at 2,300 volts and, with a few exceptions, take their power from the main bus or the house-turbine bus as desired. Motors under 25 hp. are wound for 220 or 440 volts. Further particulars regarding the types of motors used may be found in the body of the article and in the table of equipment.

The design and construction of the Hell Gate Station was carried on under the general direction of Thomas E. Murray, Inc., engineers, working in co-operation with an active construction committee, made up of a large group of central-station engineers from the several allied electrical companies of Greater New York. It was through these sources of information and the co-operation of Frank W. Smith, vice-president and general manager of the United Electric Light and Power Company, that the three articles, of which this is the first, were prepared.

FIG. 12. CONTROL ROOM IN ELECTRICAL GALLERIES

TABLE OF PRINCIPAL EQUIPMENT IN THE HELL GATE STATION

GENERAL

Plant Location—East River & 134th St., Bronx, New York City.
Character of service—Light and power.
Capacity (ultimate)—300,000 kw.
Capacity (installed)—150,000 kw.
Capacity (ultimate) per square feet of turbine-room floor space—8.4 kw.
Consulting Engineers—Thomas E. Murray, Inc.

STRUCTURES

Power Plant Building (Containing boiler room and turbine room):
Dimensions—Length, 365 ft.; width, 245 ft.; height, 124 ft.
Type of construction—Brick curtain walls on steel frame; concrete foundation; reinforced-concrete floors.
Subdivisions—Boiler room, 147 ft. wide, 365 ft. long; turbine room, 98 ft. wide and 365 ft. long.
Electrical Galleries:
Dimensions—Length (present), 212 ft.; length (ultimate), 363 ft.; width, 105 ft.; height, 124 ft. (7 stories).
Type of construction—Service and control sections of structural steel and brick with reinforced-concrete floor arches; switching gallery of reinforced concrete and brick.
Outside cable-road structure—Structural steel.
Cubic feet of ultimate building (electrical galleries and boiler and turbine building) per kilowatt of ultimate capacity—52.7.
General Contractors . . . . The U. S. Structural Co., Inc.

BOILERS AND SUPERHEATERS

Make of boilers—Springfield.
Type of boilers—Cross-drum, sectional, water-tube.
Number—Ultimate, 24; installed, 12; per group, 6.
Width of firing aisles—Two outside aisles, 17 ft.; center of groups, 26 ft.; between groups, 19 ft.
Areas and volumes per boiler—Water-heating surface, 18,900 sq.ft.; projected grate area, 472 sq.ft.; furnace volume, 8,000 cu.ft.; superheating surface, 2,135 sq.ft.
Ratios—Water-heating surface to grate surface, 40; water-heating surface to kw. installed,—1.51; water-heating surface to boiler-room floor area (ultimate basis), 8.46; furnace volume to water-heating surface, 0.423; furnace volume to projected grate area, 16.9; superheating surface to water-heating surface, 0.113.
Size of boiler tubes—Diameter (outside), 3 in.; length, 20 ft.; thickness, No. 10 gage.
Boiler pressure (gage)—250 lb.
Make of superheater—The Superheater Co.
Type of superheater—Elseco.
Superheat at 200 per cent rating—200 deg. F.
Total steam temperature at 200 per cent rating—607 deg. F.
Type of boiler setting—Duplex.
Construction of setting—22 in. of Harbison-Walker ("Woodlawn") firebrick, 4 in. of Sil-O-Cel insulating brick, sheet of asbestos board, cased with steel; vertical and horizontal expansion joints; air-cooled Drake Blocks in lower part of combustion chamber.

STOKERS

Number per boiler—2.
Make—American Engineering Co.
Type—Taylor *AA*7.
Number of retorts—Per stoker, 14; per boiler—28.
Drive—25-hp., squirrel-cage General-Electric motors with Lewellen variable-speed transmission (8 of these per group of 6 boilers) and Morse chains.
Clinker grinders—Made by American Engineering Co.; two grinder rolls per boiler, each driven by a two-speed 10/5 hp., squirrel-cage General-Electric motor.

SPECIAL BOILER EQUIPMENT

Soot blowers—Diamond Power Specialty Co.; 24 heads per boiler.
Tube cleaners—Lagonda Mfg. Co.
High-pressure drip pumps—4 simplex, double-acting pumps made by M. T. Davidson Co.
Boiler gage glasses—Inclined glass type, made by Ernst & Co.
Other equipment listed under "Draft," "Valves," etc.

DRAFT (GENERAL)

Type—Balanced.
Make of control—The Engineer Co.

INDUCED-DRAFT EQUIPMENT

Number of fans—1 per boiler.
Make of fans—B. F. Sturtevant Co.
Fan Drive—Direct-connected, 198 hp., brush-shifting, General Electric motors, with remote control by draft regulator.
Capacity of each fan—140,000 cu.ft. per min. at 6-in. pressure.

FORCED-DRAFT EQUIPMENT

Number of fans—4 for each group of six boilers.
Make of fans—B. F. Sturtevant Co.
Fan drive—Direct-connected, 202-hp., brush-shifting, General-Electric motors, with manual control.
Capacity of each fan—120,000 cu.ft. per min. at 7 in. pressure.

CHIMNEYS

Built by—Post & McCord.
Number—1 for each group of 6 boilers.
Type—Brick-lined steel stack.
Size—Height above firing-aisle floor, 258 ft.; inside diameter, 21 ft.; weight, 425 tons.
How supported—On roof steelwork.

COAL HANDLING

Supply received by—Barge (primarily) and railroad (secondarily).
Coal towers—Number, 2; make, Maine Electric Co.; capacity (each), 250 tons per hour; coal crusher in tower, double-roll driven by 52 hp. variable-speed, induction motor; tower self-propelled by 7½- and 22-hp. motors.
Cableways—Number, 2 (inner and outer); capacity, 250 tons per hour (each); make, Mead-Morrison Mfg. Co.
Bunkers:
Make—Post & McCord Co.
Number and capacity—One 250-ton at end of each single aisle; one 400-ton at end of each double aisle; total (ultimate) capacity, 3,300 tons.
Yard storage capacity—100,000 tons.
Ratio tons storage capacity to ultimate kw. installed—0.33.
Method of reclaiming from storage—Maine Electric Co. drag-scraper and skip hoist and Mead-Morrison Mfg. Co. cableway.
Coal weighing—Streeter-Amett automatic weigher with Fairbank's scales on cableway tracks and one Bergen-point Iron Works weigh larry in each firing aisle (larry capacity 25 tons in double aisles and 15 tons in single aisles).

ASH HANDLING

Type—Hydraulic sluicing system.
Installed by—U. S. Structural Co. and Post & McCord.
Capacity (ultimate)—25 tons per hour.
Supply pumps—6 ultimate, 3 present, 5,000 gal.-per-min. Lea-Courtney centrifugal pumps driven by 125 hp., squirrel cage General-Electric motors.
Disposal—Loaded to barge or motor truck by Cleveland Crane & Engineering Co. gantry crane with 2¼-yd. bucket.

TABLE OF PRINCIPAL EQUIPMENT IN THE HELL GATE STATION—CONCLUDED

BOILER FEED

Sources and character of makeup—City water supply of high grade requiring no treatment.
Feed pumps:
Size and type—6 in., 4-stage centrifugal.
Number per group of 6 boilers—3.
Make—Worthington Pump and Machinery Corp.
Capacity (each pump)—1,000 gal. per min.
Drive (pumps of 1 group)—1 pump direct-connected to 320 hp., 2,100-r.p.m. Terry Turbine; 2 pumps—direct-connected to 375 hp., 1,750-r.p.m., General Electric variable-speed induction motors.
Feed-water heaters (per group of 6 boilers):
Closed—2 (Wheeler Condenser & Engineering Co.) of 350,000 lb. per hr. capacity (each).
Open—1 (Cochrane) of 1,000,000 lb. per hr. capacity.
Temperatures at closed heaters—Inlet, 70 deg.; outlet, 150 deg.
Temperatures at open heaters—Inlet, 150 deg.; outlet, 210 deg.
Feed-water regulation—S. C. Regulator Co.
Eductor condensers for high-pressure packing steam on 35,000-kw. turbines—Schutte-Koerting Co.
Thermostats on heat-balance system—Tagliabue Co.

PRIME MOVERS

Make	General Electric Co.	Westghse. Elec. & Mfg. Co
Type	Curtis, horizontal	Tandem compound
Number (installed)	2	2
Rated capacity per unit	35,000 kw. (35,000 kva.)	40,000 kw. (43,750 kva.)
Space occupied	40 ft. long, 20 ft. wide, 13 ft. high	70 ft. long, 20 ft. wide, 20 ft. high
Number of stages	20 (single row)	
Speed	1,500 r.p.m.	1,200 r.p.m.
Steam pressure and superheat at throttle	250 lb. gage and 200 deg. F	250 lb. gage and 200 deg. F
Type of generator	3-phase, 25 cycle, 11,400 volts, Y-connected	3-phase, 60 cycle, 13,200 volts, Y-connected
Ventilation of generator	65,000 cu.ft. per min.	140,000 cu.ft. per min.
Exciters	95-kw., direct connected	135 kw., direct-connected
Lubrication (individual units)	1 oil cooler, 1 geared pump, 1 turbine-driven emergency pump	1 oil cooler, 1 geared pump, 1 turbine-driven emergency pump
Lubrication (all units)	1 batch filter (made by Richardson-Phenix Division) to filter oil for all units	

HOUSE TURBINES

Type—Horizontal, non-condensing.
Make—Westinghouse Electric & Mfg. Co.
Number (installed)—2 (1 for each group).
Rated capacity per unit—2,000 kw. (2,500 kva.).
Speed—3,600 r.p.m.
Type of generator—3-phase, 60-cycle, 2,300-volt.
Type of service—Supplies current to as many motor-driven auxiliaries as necessary to maintain heat balance; turbine exhaust delivered to feed water in open heater.
Exciters—2, 25-kw. 250-volt exciters for each unit (1 driven by a Terry Turbine and 1 by a General Electric motor).

CONDENSERS

Type	Surface, two-section	Surface, two-section
Make	Worthington Pump & Mach. Co.	Westinghouse Elec. & Mfg. Co.
Used with	35,000 kw. turbines	40,000-kw. turbines
Number (installed)	2	2
Tube surface	50,000 sq.ft.	50,000 sq.ft.
Sq.ft. of tube surface per rated kw. of prime-mover	1.43	1.25
Circulating pumps		
Number and make	2, Worthington, per condenser	2, Westinghouse, per condenser
Drive	Direct-connected 400 hp. General Electric motors.	Direct-connected 350 hp. Westinghouse motors
Capacity	35,000 gal. per min. (each).	35,000 gal. per min. (each)
Capacity per kw. installed	2 gal. per min.	1.75 gal. per min.
Hotwell pumps	2-1,350 gal. per min., Worthington, per condenser, driven by General Electric motors	2-1,200 gal. per min., Westinghouse, per condenser, driven by Westinghouse motors
Type of screens	stationary, bar, trash screens.	
Air Pumps		
Number per condenser, make and type	4 Worthington, 2-stage steam jet, air ejectors, 2 intercoolers	2 Westinghouse Leblanc, direct connected to 50 hp. Westinghouse motors, Elliott Twin strainer on water inlet
Capacity	18 cu.ft. per min. at 29 in. vacuum per unit of 2 ejectors	12 cu.ft. per min. at 29 in. vacuum per pump

PIPING

Steam & Boiler feed—Over 5-in., wrought steel with Vanstone joints; 5-in. and under, wrought iron.
Fittings—Over 1½-in., cast steel; 1½-in. and under, steel, screwed.
Piping furnished by Whitlock Coil Pipe Co. and Ballwood Co.
Fittings furnished by J. W. Kellam, and Reading Steel Castings Co.
Piping erected by Almiral & Co.
Condenser piping—Cast Iron, Croll Reynolds Co.

VALVES

Steam Valves (Type and make):
Safety—Pop; Consolidated Safety Valve Co.
Non-return—Angle; Foster Eng. Co.
Blowoff—Special angle valve in series with blowoff cock; Hancock Inspirator Co.
Atmospheric relief—36-in. horizontal; Atwood & Morrill.
Gate—Chapman Valve Co.; Hancock Inspirator Co.
Other—Globe; Hancock; Throttle, Hancock; Bleeder throttle, Crane Co.; Ball check, Wheeler Condenser & Engineering Co.; Stop-check, Nelson Valve Co.; Multiport, H. S. B. W.-Cochrane Corp.; plug cocks, Pratt & Cady Co.; Boiler try cocks, Ernst & Co.
Motor—Operated valve; Payne Dean, Ltd.

HEAT INSULATION (STEAM AND HOT WATER)

High-pressure steam lines—2 layers, each 1¾ in. thick, of 85 per cent magnesia separated by 2 layers of ⅛-in. asbestos millboard; finished with sewed canvas.
Low-pressure and exhaust lines—85 per cent magnesia 1 in. thick, finished with sewed canvas.
Hot-water lines—85 per cent magnesia, 2 in. thick.
Boiler headers and drums—85 per cent magnesia ½ in. thick over 3½ in. "Sil-O-Cell" Brick.
Feed water heaters—85 per cent magnesia, 2 in. thick.
Pipe covering supplied and applied by—Robt. A. Keasby Co.
"Sil-O-Cell" boiler insulation furnished by Celite Products Co.

AIR COMPRESSORS

Service—Cleaning, etc.
Number and Type—2 horizontal, 2-stage with intercoolers, driven by 108-hp. synchronous motors.
Make—Chicago Pneumatic Tool Co.
Capacity (each)—613 cu.ft. per min.
Air pressure—100 lb. (gage).

SPECIAL CENTRIFUGAL PUMPS

Pumps for booster service—4, Goulds Mfg. Co., 750 gal. per min., 50-lb. pressure, driven by 40-hp. squirrel-cage, 1,750-r.p.m., Westinghouse motors.
Pumps for closed heater condensate—4, Goulds Mfg. Co., 200 gal. per min., 70-ft. head, driven by 10-hp. squirrel-cage Westinghouse motors.
House service pumps—2, Lea-Courtenay, 1,000 gal. per min., 231 ft. head, driven by 100-hp. squirrel-cage General-Electric motors.
Pumps for fresh-water service—2, Goulds Mfg. Co., 100 gal. per min., 150-ft. head, driven by 10-hp. squirrel-cage Westinghouse motors.

FIRE PUMPS

Number & Type—One 2-stage, Cameron, horizontal centrifugal, direct-connected to 190-hp. Terry Turbine.
Capacity—1,000 gal. per min.
Head—465 ft.

VENTILATING FANS

Make—Buffalo Forge Co.
Number, capacity and drive:
General ventilation—eight 20,000 cu.ft. per min., driven by Westinghouse 20-hp. squirrel-cage motors.
Battery room—One 4,200 cu.ft. per min., driven by Westinghouse 2-hp. motor.

GAGES, METERS AND INSTRUMENTS (MAKE, TYPE AND NUMBER)

Ashcroft Mfg. Co.:
Indicating pressure gages for steam, water, air, oil, etc.—70.
Ashton Valve Co.:
Main switchboard pressure gages—2.
Main steam-pressure gages—2.
Pilot gages—2.
Bailey Meter Co.:
Three-point draft gages—4.
Boiler meters—12.
Bristol Co.:
Air-duct-pressure recording gages—4.
Combination steam and water-pressure recording gages—2.
Recording thermometers for atmospheric exhaust leakage—2.
Recording thermometers for turbine superheat—4.
Recording thermometers for feed water—2.
Recording thermometers for intake circulating water—1.
Recording steam-pressure gages—2.
Recording thermometers for main-turbine exhaust—4.
Recording pressure gages for main-turbine inlet—4.
Recording ammeter (with Warren synchronous motor) for recording condenser salt-water leakage—1.
Combination inlet and exhaust pressure recorders for house turbine—2.
Crosby Steam Gage and Valve Co.:
Standard test pressure indicating gages—2.
Precision Instrument Co.:
Compound pressure-indicating gages for open heaters—2.
Indicating air-pressure gages for forced draft fans—8.
Republic Flow Meter Co.:
Integrating and recording flow meters for feed water—4.
Integrating and recording flow meters for condensate—4.
Integrating and recording meters for city-water makeup—2.
Taylor Instrument Co.:
Indicating thermometers—58.
Mercury barometers—1.
Mercury vacuum gages—4.
Barometer cases for testing—2.
Room-temperature thermometers—2.
Yarnall Waring Co.:
V-notch blow-down meter with leakage recorder—1.

SPECIAL EQUIPMENT

Traps on 40,000-kw. turbines—C. E. Squires Co.
Traveling cranes in operating room (Morgan Engineering Co.).
One 110-ton, 95-ft. span, 80-ft. lift, 10-ton auxiliary hook.
One 90-ton, 95-ft. span, 80-ft. lift, 50-ton auxiliary trolley and hook.
Caterpillar crane—One, Orton & Steinbrenner Co., 12-ton, 50-ft. boom, bucket-handling, gasoline-engine drive, for use in coal storage.
Subway Grating (for runways, etc.)—Irving Iron Works Co.

ELECTRICAL GALLERY EQUIPMENT

Switching equipment (Westinghouse)—Remote-control, isolated-phase, electrically operated oil switches; one 12-section generator benchboard and one 32-section feeder switchboard controlling 96 feeders and 7 bus ties.
Meters—Westinghouse, General Electric, Leeds Northrop.
Reactance coils (Metropolitan Device Corporation)—Single-phase on generators, bus ties, outgoing feeders and station ties.
Storage batteries (Electric Storage Battery Co.)—Two 118-cell 240-ampere-hour batteries for switch control; one 104-cell 240-ampere-hour battery for emergency lighting.

How To Compute a Complete Motor Installation

By EDGAR P. SLACK
Assistant Electrical Engineer, Underwriter Laboratories

A Table is given which summarizes the National Electrical Code rules for the installation of motors, and some problems are worked out showing how to apply the table to motor circuits

AFTER the size of the motor and the service to which it is to be applied are known, there are three questions with regard to its wiring and fuses that must be answered before the actual installation can be made. These are: (1) How large must the lines be? (2) What size cutout is required to protect the line? (3) Is an extra cutout required to protect the motor, and if so how large should it be? These items are covered separately by rules in the National Electrical Code, but in a practical case they must be computed together, for they depend to a large extent upon one another as well as on the rating and type of the motor.

For convenience in making these computations, the accompanying table has been prepared. It contains a summary of all the Code rules dealing with the sizes of line wire and cutouts. Referring to the left-hand side of the table, it will be seen that it is divided into three sections: Motor Cutouts, Line Cutouts, and Capacity of Line. Under these headings the subjects are subdivided to answer the various questions that may arise with regard to the different conditions that must be satisfied. For example, under the heading, "Capacity of Line" this division is divided into two sections—"Smallest Size Allowed" and "Larger Sizes Recommended in Special Cases." The former is easily answered in that the rules state that all "branch circuits supplying any motor must have carrying capacity of at least 110 per cent of the motor's rating." However, when the second part is to be answered, a number of conditions are involved, such as "motors having large starting currents," "motors having peak loads," etc. The method of using the table can best be illustrated by considering some typical installations. Rubber-covered wire, being the most common, is to be used in all cases with the table.

Case 1: This is a 7½-hp. 230-volt direct-current motor having a continuous rating of 30 amperes to be used to operate a group of small machines. The protection is to be by fuses (see Fig. 1). Referring to the table, it is found under section "Capacity of Line," that the line must be large enough to carry at lea t 110 per cent of the motor's rated current, or in this case 110 per cent of 30, or 33 amperes. This calls for a No. 8 wire, which is rated at 35 amperes. This machine is not of a type having large starting current, neither is it used for peak-load service, so that this case does not fall under those mentioned in the table where a larger size of wire is recommended. No. 8 wire may therefore be taken as the size, noting, however, that it may have to

USEFUL RULES IN COMPUTING SIZE OF WIRE AND CUTOUTS FOR MOTOR INSTALLATIONS

CAPACITY OF LINE

Smallest Size Allowed

Branch circuit supplying any motor must have carrying capacity at least 110 per cent of motor rating

Larger Sizes Recommended in Special Cases

Motors having large starting current (squirrel cage, etc.)

Started with auto-starter.		Started without auto-starter
Motor Rtg. 0-30 Amp.	Motor Rtg. Above 30 Amp.	
250%* of Motor Rtg.	200%* of Motor Rtg.	300%* of Motor Rtg.

*In that portion of motor circuit not protected by motor cutout.

Motors having peak loads

Class of Service	Percentage of Motor Rating: 5 Min. Rating	10 and 15 Min. Rating	30 and 60 Min. Rating	120 Min. Rating	Continuous Rating
Operating valves raising or lowering rolls	110	120	150	200	250
Rolling tables	110	120	135	180	200
Hoists, rolls, ore and coal-handling machines	110	115	120	150	170
Elevators, shop cranes, tool heads, pumps, etc.	110	110	110	120	140

LINE CUTOUT

Largest Size Allowed

Motors having Large Starting Current		Motors not having Large Starting Current	
Fuse (R.-C. Wire)	Circuit Breaker	Fuse	Circuit Breaker
Value in Table C corresponding to capacity of line	130 Per Cent of capacity of line	Capacity of line	130 Per Cent of Capacity of line

MOTOR CUTOUT

When Required

For each continuous rated motor of over 2 horsepower used for constant-load duty:

Having large starting current	Not having large starting current
Motor cutout may be shunted or cut out of service while starting. Figure it independently of line cutout, as below	Motor cutout must be in circuit continuously. Usually make line cutout serve also as motor cutout by meeting the rule given below by using proper line capacity

For:
(1) Continuous rated motors of 2 horsepower or less; or
(2) Motors of other than continuous rating; or
(3) Motors used on other than constant load duty.

Line cutout is considered sufficient.

Largest Size Allowed

Fuse (or thermal cutout)	125% of Motor Rtg., except when none of required capacity exist; then use next higher standard rating
Circuit Breaker	Time limit: 125% of Motor Rating Instantaneous: 160% of Motor Rating

be changed when all the items are taken into account. The next consideration is the line cutout. The table shows, under the headings, "Line Cutout" and "Motor Not Having Large Starting Current," that the largest fuse allowed equals the capacity of the line; that is, 35-ampere fuses would be used for a No. 8 wire size.

Now consider the motor cutout. This motor (1) having a continuous rating (2) of over 2 hp. and (3) being used for constant-load duty, requires protection

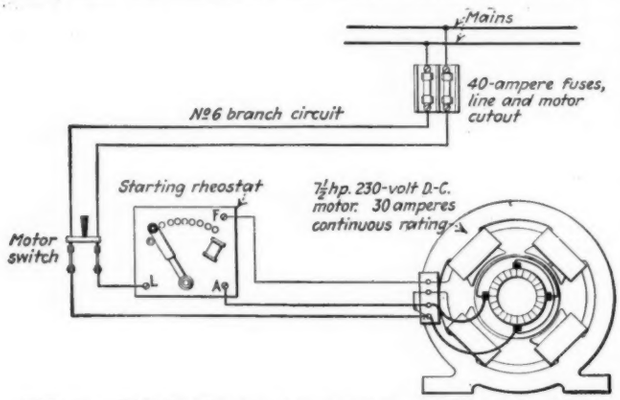


FIG. 1. CONNECTIONS OF DIRECT-CURRENT SHUNT MOTOR TO STARTING RHEOSTAT

by a motor cutout. Moreover, since no permission is given to shunt the motor cutout or to cut it out of service during starting, it follows that this cutout will be continuously in circuit, the same as the line cutout. In figuring the size of the motor fuse which, as indicated at the bottom of the table, is 125 per cent of the motor's rating, it is generally desired to use the largest size permitted. For the motor in the problem the largest size cutout is found by taking 125 per cent of 30, or 37.5 amperes, a 40-ampere fuse being permitted as the next higher standard rating. Obviously, in a simple circuit it would serve no purpose to have one pair of 35-ampere fuses at the supply end to protect the line and a pair of 40-ampere fuses at the motor end to protect the motor, since on overload the smaller fuses would be the ones to blow. The thing to do is, therefore, to use the 40-ampere fuses, as required for protecting the motor, but to place them at the supply end of the line and make them serve also as the line cutout, increasing the size of the line to a value that will be protected by the 40-ampere fuses. The table of carrying capacity shows that a No. 6 rubber-covered wire is required. The correct connections and sizes are therefore as shown in Fig. 1.

Case 2: This is a 40-hp. 440-volt three-phase squirrel-cage motor having a continuous rating of 58 amperes, to be operated by an auto-starter and used for normal operating service. The line is to be protected by fuses and the motor by the overload trip coils of the auto-starter (see Fig. 2). Referring to the table, the branch circuit must have a capacity of at least 110 per cent of 58, or 64 amperes, which requires a No. 4 rubber-covered wire, and is rated at 70 amperes. Since this wire is used on an induction-motor circuit, the Code allows fusing it according to Table C, in the carrying-capacity table, therefore the circuit can be fused with 90-ampere fuses. But this motor having a large starting current, a 90-ampere fuse would be almost sure to blow on starting, and so a larger-sized line is recommended between the supply and the auto-starter, this line to have a capacity of 200 per cent of the motor's rated current, as found in the table under the headings "Capacity of Line," and "Started with Auto-Starter."

Taking 200 per cent of 58 gives 116 amperes, which requires a No. 0 wire. The line fuses may be 200-ampere in size since the line can be fused according to Table C of the Code wire table. The table given herewith shows under the headings "Line Cutouts" and "Motors Having Large Starting Current" that this motor requires protection by a motor cutout. If the auto-starter is designed so as to open all the conductors of the circuit automatically on overload and has two trip coils, one in each of two phases, it will serve as a circuit breaker and may be so used when subjected to competent supervision. If the trip coils are of the usual time-limit type, they may be set to open at 125 per cent of 58, or 73 amperes. The part of the circuit between the auto-starter and the motor is protected by the motor cutout and may have a capacity of 110 per cent of 58, or 64 amperes; that is, No. 4 wire may be used as computed above. The connections and sizes to use are consequently as shown in Fig. 2.

Case 3: This is a 25-hp. 230-volt direct-current elevator motor having a 120-minute rating of 100 amperes (see Fig. 3). The smallest capacity of line permitted would be 110 per cent of 100, or 110 amperes, and such a line would be fused with 110-ampere fuses. This motor being subject to peak loads, however, 110-ampere fuses would be likely to blow under normal

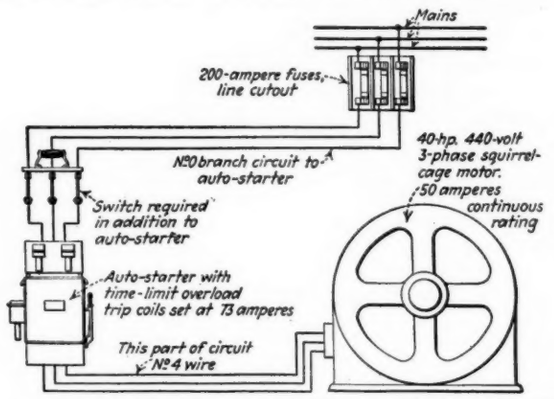

Mains
200-ampere fuses, line cutout
№0 branch circuit to auto-starter
40-hp. 440-volt 3-phase squirrel-cage motor. 50 amperes continuous rating
Switch required in addition to auto-starter
Auto-starter with time-limit overload trip coils set at 73 amperes
This part of circuit №4 wire

FIG. 2. CONNECTIONS OF INDUCTION MOTOR TO AUTO-STARTER

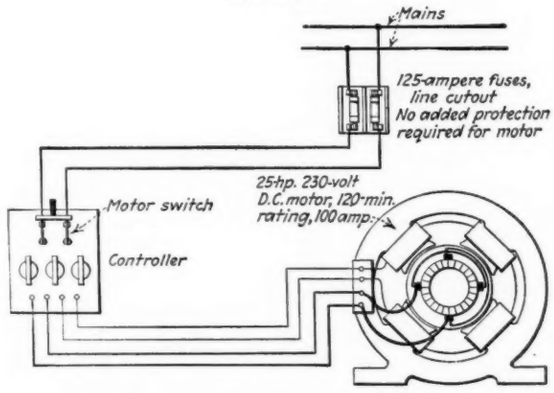


FIG. 3. GENERAL ARRANGEMENT OF ELEVATOR MOTOR CIRCUITS

operation, and therefore a larger-capacity line is recommended; namely, 120 per cent of 100, or 120 amperes, as stated in the table. This calls for a No. 0 line, which, being rated 125 amperes, permits the line fuses to be of the 125-ampere size. Referring now to the motor

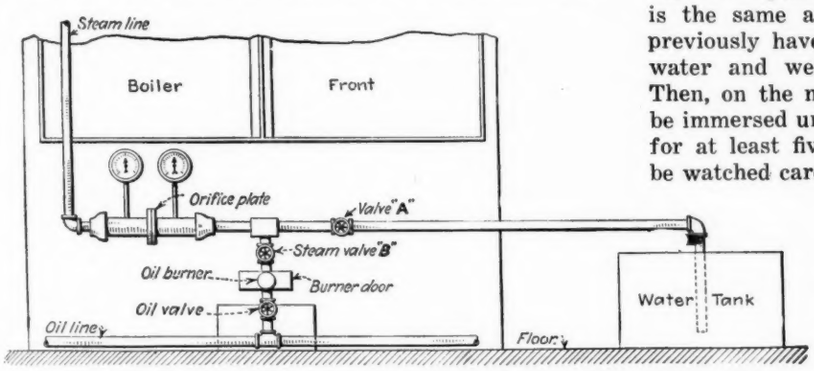
cutout, the table shows that since this motor is not used for constant-load duty, and also because it is not continuously rated, the line cutout is considered sufficient to protect the motor. The connections and sizes shown in Fig. 3 are therefore correct for this case. By following the methods used in these representative cases, any practical motor installation can be worked out without difficulty. In the foregoing examples, the sizes of the branch circuits have been selected to meet the Code requirements, and no consideration has been given to the volts drop in the line. Where the line exceeds 400 or 500 ft. in length, the volts drop should be checked as explained in the article, "How to Find Voltage-Drop in Electric Circuits," in the Dec. 27, 1921, issue.

Oil-Burner Steam-Consumption Measurement

By Allen F. Brewer

In boiler plants burning fuel oil and using steam for atomization, it is seldom that provision is made for measuring the consumption of the steam used for this purpose. The figure specified by the manufacturer is generally used as a constant in determining this consumption.

The steam consumption of oil burners depends to a large extent upon the proficiency of the fireman. Careful handling of the fires in co-ordination with the draft, in order to maintain normal CO of, say, 13.5 per cent and meet load demands, should result in the most economical consumption of steam for atomization. On the other hand, if the CO_2 is allowed to drop, the evaporation will also fall off and more steam and oil than theoretically required, will have to be used to keep up the evaporation and meet the load. For economy and efficient operation it is advisable to have the consumption of steam measured continuously; where this is not possible it should at least be determined when running a test on the boilers.



GENERAL ARRANGEMENT OF ATTACHMENTS FOR MEASURING STEAM CONSUMPTION

Wherever a steam-flow meter can be obtained, it is advisable to use one. The resources of the smaller plant will not generally allow it to purchase one for intermittent purposes only. Therefore, a home-made idea for condensation and weighing of the resultant condensate is the next best resort.

The arrangement of burner and connections is shown in the illustration. This also shows the principles of a practical scheme to measure the steam consumption. The apparatus required comprises: two 2-in. nipples about 12 in. long; two reducers of 2-in. by the size of the steam pipe (call this ½-in.) sufficient ½-in. pipe to make up connections from a tee at the burner line to the measuring tank; one ½-in. valve *A;* two tested pressure gages; and a pair of 2-in. flanges for joining the 2-in. nipples and holding the orifice plate. This plate may be a simple blank flange or a thin metal plate with a ¼-in. hole drilled accurately in the center. It is clamped between the flanges with suitable gaskets on either side to prevent leakage. The purpose of this orifice plate is to set up a difference in pressure which can be accurately measured by the respective pressure gages on either side of the flange.

It will be found easiest to weigh the condensate to be obtained, or a tank may be substituted and the contents gaged. To facilitate handling, a short length of hose will be found more adaptable than pipe for leading the steam into the measuring tank.

During the test operation should be carried on as usual, valve *A* being closed and steam to the burner governed by valve *B*. Readings of the pressure gages should be taken at regular intervals, say every fifteen minutes. At the end of the test these readings should be averaged. Under normal conditions there will be a difference in pressure of about 12 to 18 pounds.

To complete the measurements, it must be possible to cut the boiler off the line for perhaps half an hour. Steam valve *B* to the burner should then be closed and valve *A* opened slowly until the pressure difference is the same as before. The measuring tank should previously have been filled about one-third full of cold water and weighed, or the depth accurately gaged. Then, on the minute, the open end of the hose should be immersed under the water and steam allowed to flow for at least five minutes. The pressure gages should be watched carefully to note that no change in pressure occurs. At the end of the period the hose should be removed from the tank and the latter again weighed, or the contents gaged. The difference in weight, (or depth, converted to pounds of water) will be approximately equal to the amount of steam used by the burner for the period measured. From this figure a rate in pounds of steam per hour consumed by the burner can readily be arrived at and will thus make possible more intelligent operation of the boiler.

There is an impression, which is quite current, that the Diesel engine cannot burn oil unless it is a refined product and at least 22 to 24 deg. Baumé gravity. To the contrary, there are in service a large number of Diesel oil engines that are burning the heaviest of Mexican and Texas Gulf Coast fuel. Where the difference in the cost of the so-called Diesel fuel oil and boiler is one cent or less, it will generally be found that the refined oil is better, since the operation of the engine will probably be a little superior. Where the difference in price is over one cent per gallon, the owner of a Diesel engine should investigate the use of heavy boiler oil. It must be filtered in order to remove all the dirt particles. This may be done either by centrifugal filter or by a gravity filter process, combined with straining through a cloth. In addition, it will often be found necessary to raise the temperature of the oil enough to allow it to be handled through the piping without any great resistance.

Recent Developments in the Gas and Oil Turbine*

By PROF. W. SCHUELE

THE problem of the gas and oil turbine has busied a great number of engineers during the past twenty years. In spite of these researchers and their many inventions, we fail to find a gas turbine in commercial service. In Germany the Holzwarth turbine, built by Thyssen & Co., is undergoing a series of severe tests. In other countries nothing has been done save the French experiments with the Armengand-Lemale turbine, which work has been discontinued.

The Holzwarth gas turbine is supposed to follow the fundamental working principles of the Otto gas engine, in which heat is added at constant volume and after performing work the remainder is rejected at constant volume. In fact, the cycles are not identical, since precooling of the gases of combustion has been found to be necessary in the turbine. This precooling is absent in the reciprocating gas engine, although there is an unavoidable cooling during combustion by the jacket cooling water.

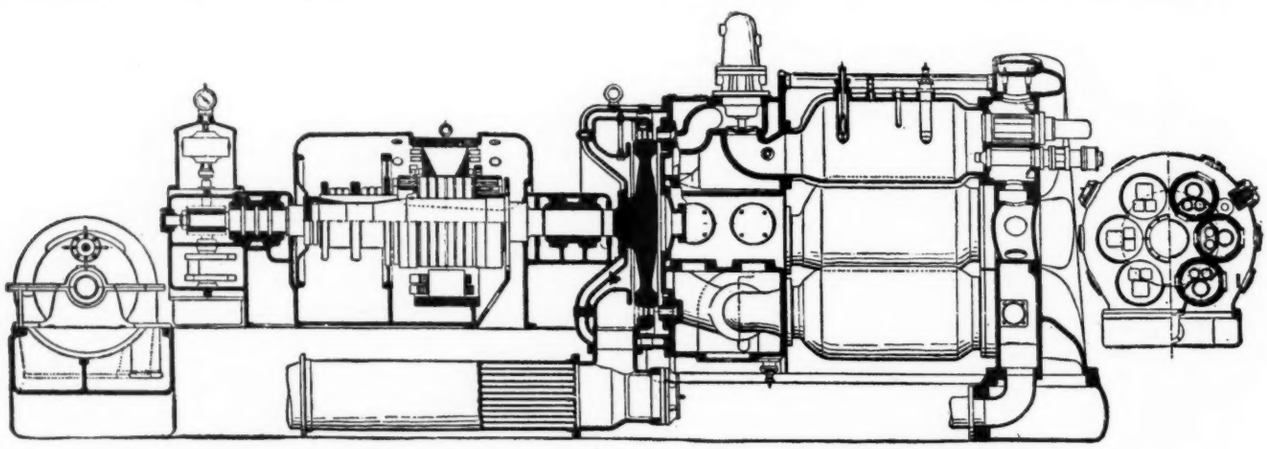


FIG. 1. OIL TURBINE BUILT AND TESTED OUT AT THE THYSSEN WORKS

Engineers will recognize the thermal disadvantage that lies in this precooling, for if the heat or part of the heat of combustion is allowed to escape, instead of a working process we have merely a heating and cooling cycle. The precooling of the burning gases, in the gas turbine, which are at a temperature of 2,800 to 3,500 deg. F., is in sharp opposition to the principles which have, in the gas engine, proved to be fundamentally sound and may be looked upon as the main reason for the failure of so many experimental turbines.

In the constant-pressure gas turbine combustion is carried out continuously and the gases pass out of the nozzle onto the blades at a uniformly high pressure.

The blade surfaces of this type of turbine attain the temperature of the uninterrupted stream of hot gas flowing through the machine. This temperature cannot be held higher than 800 to 900 deg. F. if burning of the blades is to be avoided. As it is impossible to reduce the temperature from that of combustion, say 3,200 deg. F. to 900 deg. adiabatically at the available pressure drop in the nozzles of 150 to 300 lb., the gases must be cooled before entering the turbine. This results in a thermal loss, and an economic loss as well, by reason of the reduced output per machine. The cooling is required not alone to protect the turbine wheel, but also to protect the combustion space, where a gas temperature of 3,500 deg. F. is constant. This has been the stumbling block in gas turbine progress up to the present time.

To avoid this precooling loss, the gas and air mixture in the Holzwarth turbine is distributed to from six to ten combustion chambers. The first rise in pressure after combustion starts, closes the inlet valve and opens the burner valve. The gases pass through this valve into the turbine, the potential energy being transformed to kinetic energy at the nozzle, the entire events taking less than one-tenth of a second. This process is repeated by each chamber in rapid succession. Each combustion chamber has a charging as well as a firing period, and as in the gas engine, the cooling jacket combustion chamber absorbs less than 10 per cent of the developed heat.

It is possible to operate the wheels with a gas temperature of 1,800 deg. F. if the contact lasts only a short time and is followed by contact with cold air. As for blading, soft electro-iron is used, and this metal appears to stand up satisfactorily, the blades being threaded and screwed into the wheel rim.

The action of the gases in the Holzwarth gas turbine is by no means similar to the action of steam in a steam turbine. The steam issues in a steady stream, while the gas issues from the nozzles of the gas turbine as a succession of impacts, sounding much like machine-gun fire. The bucket wear in the gas turbine is correspondingly increased.

In the Holzwarth machine wheels with pressure stages are not used. The steam turbine has a pressure drop from, say, 13 atmos. to a final pressure of 0.05 atmos., or a ratio of 260, and it would seem that,

*Extract of Lecture before the German Union of Electro- Technicians, Essen, Germany.

since the gas turbine has a step-down ratio of from 10 to 20 by 1, a wheel with a single-pressure stage should be ample to give this pressure ratio. One need only consider whether a wheel with several rows of velocity buckets or with but one row is to be used. Fig. 2 shows the design of a 10,000-kw. turbine of 1,500 r.p.m. which is being built at the present time. The arrangement of the combustion chambers and wheel is clearly shown. Owing to the balancing of the pressure on both sides of the wheel no thrust bearings are required.

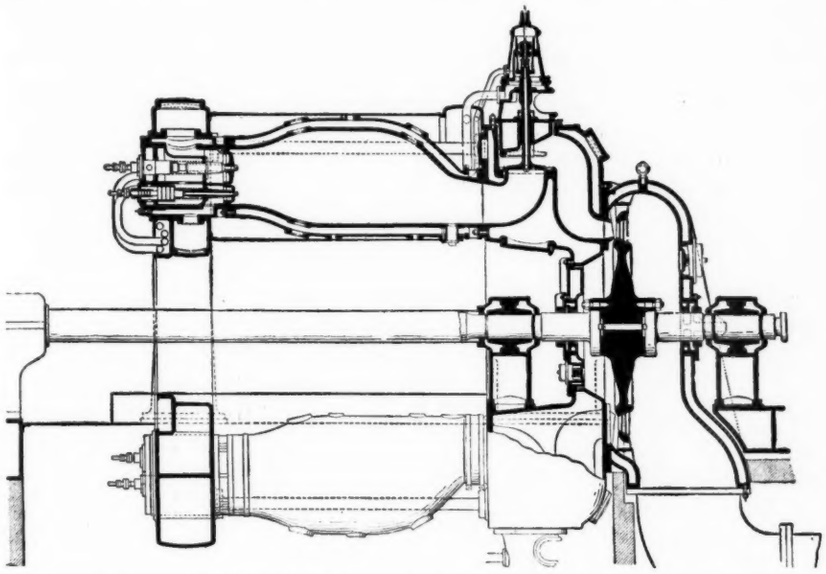


FIG. 2. DESIGN OF 10,000-KVA. GAS TURBINE NOW BEING BUILT

Everything said so far for the gas turbine applies to the oil turbine, as the machine is but slightly modified and a fuel valve added.

During the end of December, 1920, an oil turbine, Fig. 1, was built by Thyssen, according to plans of Mr. Holzwarth, and put into actual running. The six combustion chambers, each having a volume of 5.18 cu.ft., are arranged around the shaft. The oil is centrally injected into the oblong combustion chambers by an air-pressure atomizer after the chambers have been filled with fresh compressed air. The oil cloud thus produced fills the chambers completely and is ignited by several high-tension spark plugs not shown. The first experiments showed that in this manner heavy oil may be burned without residue and the combustion and resulting pressure are the same as when gas fuel is used. The temperature must be kept high enough to insure ignition, and oil cloud must not come into contact with any cold walls. It is not impossible that benzol-carbon hydrates may be burned without residue. During the experiments it was found that a simultaneous performance of the six chambers could be kept up with a normal rotation of the shaft of 2,700 per minute. Regular running and performance experiments are to follow. Up to the present the following facts have been brought out: A medium temperature in the combustion chambers of from 875 to 1,000 deg. is secured, while in the wheel chamber, and at exhaust the temperature is from 800 to 875 deg. In a cast-steel combustion chamber 9 per cent combustion heat was taken up by the cooling water, while the duration of exhaust was found to be less than 0.1 second.

Even if good performance of the experimental gas turbine has been proved, there still remains the difficulty of conveying the greatest possible part of this performance to the shaft. Future experiments will be in the direction of obtaining effective results and improving the form of valves, buckets, the form of the wheel chamber, the time of contact and the air-cleaning system. According to the latest stage of the experiments undertaken in 1921 and the extension of the same, there is a well-founded opinion that the Holzwarth turbine will reach the same grade of development as has the steam turbine. In addition the net thermal efficiency should reach a minimum of 30 per cent in contrast with the 20 to 22 per cent obtained by the modern steam turbine.

An examination of the work done in Germany on the gas turbine leads one to feel that there is no basic reason why this form of prime mover should not be made commercially successful. The difficulties yet to be overcome are not greater than those that confronted the early steam-turbine designers. Since the cost of the steam turbine is but a fraction of the total cost of the steam-plant equipment, the gas turbine, when developed into a commercial proposition, should more than compete with other forms of engines. While a low-pressure steam turbine is a necessary appendage, if the greatest efficiency is to be obtained from the gas turbine, it is feasible to far exceed the efficiency of the present-day steam plant even though the gas-turbine exhaust heat be thrown away.

An Electrically Operated CO_2 Recorder

BY WILL G. WEBSTER

There are various types of combustion recorders on the market, nearly all of them employing some form of chemical preparation as a reagent to absorb the CO_2 in the gases. The instrument described in the following is entirely electrical in its operation. This CO_2 recorder is in principle a Wheatstone bridge in which the resistance is known in the four arms.

Before reading this description of the CO_2 recorder, the reader is referred to the article, "The Wheatstone Bridge and How it Operates," in the previous issue of *Power*. The meter is shown diagrammatically in Fig. 1, in which two of the arms, P and P_1 are spirals of platinum wire, having identical resistance under similar conditions. These spirals are contained in two separate cells in a brass block. The arms R and R_1 are made of manganin wire. They are of equal resistance and are used to complete the bridge.

If switch S is closed, a current will flow through the bridge arms. This will cause heating and change the resistance of the four arms. If conditions are the same around the different arms of the bridge, then R and R_1 will lose heat at the same rate and likewise P and P_1; consequently, if R and R_1 were equal and P and P_1 were of equal resistance before switch S is closed, they will be of equal resistance after. Therefore the bridge will remain balanced, and the gal-

vanometer G will not be deflected. Now suppose that the space in the block surrounding the spiral P_1 is filled with a substance that is a better conductor of heat than that around P. Then the heat being conducted away from P_1 faster than from P, will result in P_1 being maintained at a lower temperature and consequently a lower resistance than P. This causes the bridge to be

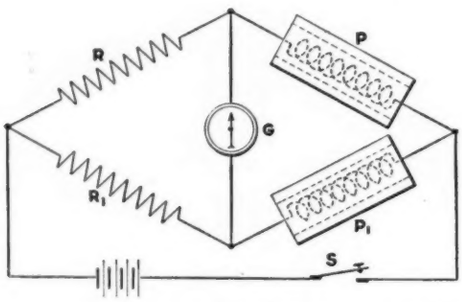


FIG. 1. DIAGRAM OF ELECTRICAL CO_2 METER

unbalanced, which will be indicated by a deflection of the galvanometer G.

The foregoing is just what happens in the electrical CO_2 meter. One spiral in one of the cells in the brass block, say P, is entirely closed and surrounded by air saturated with moisture. The air is kept saturated by having communication by a small tube with a chamber that is filled with water. Spiral P_1 is exposed to the flue gas, which is a better conductor of heat than the air, consequently P_1 will be cooler in operation than P and the bridge will be unbalanced as previously explained. The thermal conductivity of the flue gas increases as the CO_2 content increases, therefore the higher the percentage of CO_2 in the gas the cooler P_1 will be and the more the bridge will be out of balance, causing a greater deflection of the galvanometer. Now all that is necessary is to calibrate the galvanometer to read in per cent CO_2 and a direct-reading meter is obtained. In the instrument in question either an indicating or a recording galvanometer, or both may be used. The two spirals P and P_1 are so located that

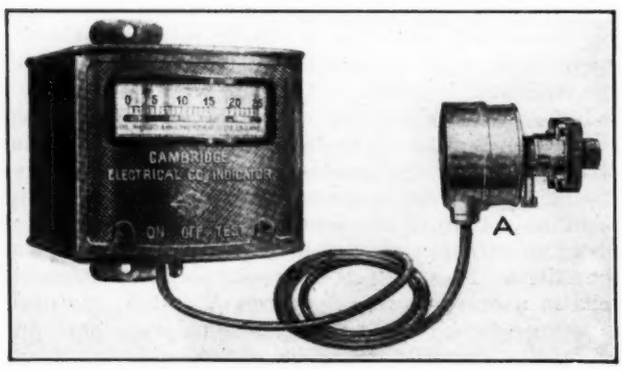
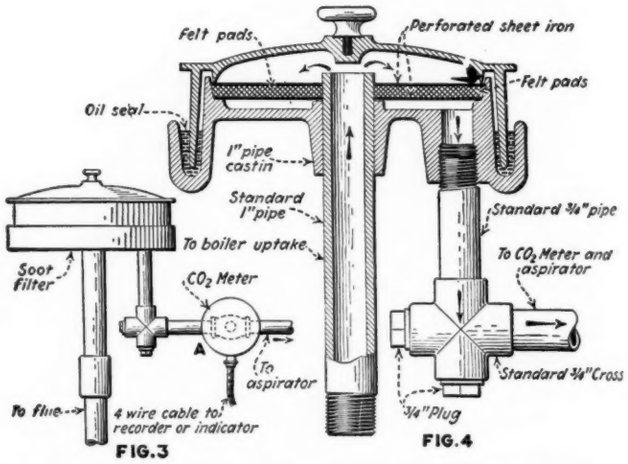


FIG. 2. ELECTRICAL CO_2 INDICATOR

they are both similarly affected by the temperature of the flue gas, therefore there is no error in the meter due to changes in temperature.

The instrument shown in Fig. 2 is of the indicating type and was devised by Dr. G. A. Shakespeare, of Birmingham University, England. The equipment is manufactured by the Cambridge & Paul Instrument Co., Ltd., London, England, which is represented by Instruments, Limited, Ottawa, Canada. In Fig. 2, A contains the Wheatstone-bridge part of the equipment, which is known as the meter and is connected as indicated at A, Fig. 3.

The soot filter is shown in section in Fig. 4, and the flow of gas is indicated by the arrows. After passing through the soot filter, the gases go through a filter of glass wool in the meter itself before passing to the brass block on one of the bridge arms. An aspirator is used to draw the gases through the meter. The indicator is a double-pivoted pointer galvanometer inclosed in a dust-proof case and connected to the meter A through a four-wire cable. A three-position switch is provided so that the indicator can be connected to three positions—On, Off and Test. When the switch is in the latter position, the reading can be checked and



FIGS. 3 AND 4. SHOW HOW ELECTRICAL CO_2 RECORDER IS CONNECTED AND SECTION THROUGH SOOT FILTER

adjusted to compensate for any variation in battery voltage. By suitable switching arrangements the indicator may be connected to meters on almost any number of boilers. The scale is graduated to read from zero to 25 per cent CO_2.

The recorder is also a galvanometer mounted in a case and provided with a clockwork to rotate the chart drum and a second clock motion which operates a pressure bar, causing the deflection of the galvanometer to be stamped on the chart, which is divided off in percentages of CO_2. The clockwork can be adjusted to stamp every minute or every half-minute as desired, and the chart drum can be adjusted to make a full revolution every 25 hours or every 2½ hours. During the interval between the periods at which the record is stamped, the galvanometer is free to take up its proper deflection, and therefore there is no error due to friction.

The storage battery required to operate the apparatus is comparatively small, one cell being sufficient to supply current to the instrument, which requires 120 milli-amperes at 2 volts, and one 20-ampere-hour cell will last about one week without recharging. On the recorder an ammeter is provided, which shows the current in the Wheatstone bridge circuit, and adjustments can be made to compensate for variations in battery voltage.

Measuring Area of Indicator Diagram

DO you understand the planimeter and how the mean effective pressure may be found with this instrument? Read this article.

THE area of a rectangle, as Fig. 1, is found by multiplying its length by its breadth or height. If *ABDC*, the top area in Fig. 1, had the side *AB* equal to 3 inches and the height equal to 2 inches, its area would be $2 \times 3 = 6$ square inches. If the length *AB* were 4 inches, as shown on the lower drawing, Fig.

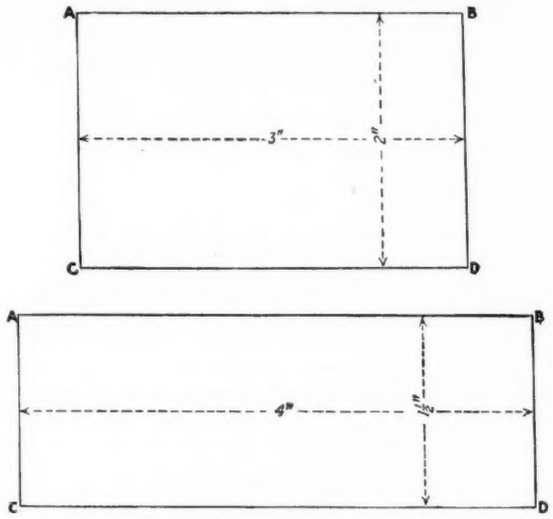


FIG. 1. EQUAL AREAS WITH DIFFERENT LENGTHS

1, to have its area equal to 6 square inches, the height *AC* must be 1½ inches, since $4 \times 1\frac{1}{2} = 6$.

Suppose we had a figure such as Fig. 2A and desired to know its average height, or in other words the height of a rectangle of equal area having the same base *AC*. We could divide the rectangle into a number of smaller rectangles as indicated in Fig. 2B. Taking up each of these rectangles in turn, we could find the height of a rectangle of equal area whose length is equal to *AC*, giving the series of areas, Fig. 2C. For example, the area of the rectangle *AEFC*, Fig. 2B, is 8 sq.in., its height *AE* is 1 in. and its length *AC* is 8 in. The height *ME* of the rectangle *EGHM* is 1 in. and the length *EG*, 6 in. The area *EGHM* is then $1 \times 6 = 6$ sq.in., and the height of a rectangle having an area of 6 sq.in. and a base equal to 8 in., would be $6 \div 8 = \frac{3}{4}$ in., as shown in Fig. 2C. We could then make of the four equivalent rectangles shown in Fig. 2C a single figure as shown in Fig. 2D whose height *A'B'* is the sum of the heights of the equivalent rectangles in Fig. 2C and whose length *A'C'* is equal to *AC* in Fig. 2A. The area of Fig. 2D will be that of Fig. 2A with the same base, but with an average height equal to the average height of Fig. 2A.

In the indicator diagram the height at any point is proportional to the pressure at this point. The average pressure is evidently equal to the average height of the diagram. If the diagram was made up of a series of rectangles as in Fig. 3, the average height could be found as was done in Fig. 2. The number of these rectangles could be increased until the figure closely conformed to the outline of the diagram as taken from the engine. It would be physically impossible to measure, individually, the number of rectangles so formed, but if the diagram area were known, this could be divided by the length, giving the average height which is proportional to the average or mean effective pressure.

Fortunately, the measuring of the diagram area is quickly accomplished by means of an instrument called the planimeter, meaning the *meter* or measurer of *planes* or areas.

This instrument is made in a variety of forms. The Amsler was the first introduced and is shown in Fig. 4. This planimeter consists of two jointed arms, one of which carries a wheel *D* with a scale upon its rim. The second arm carries a needle point *C* which is set in a fixed spot on the drafting board, while the tracing point *A* of the first arm is moved along the lines outlining the diagram, as in Fig. 5. Starting with the tracing point at any position as *A* in Fig. 5, the stationary point is set at some position outside the diagram as *O*, and the wheel scale is set to read zero. The stationary point should be so located that the planimeter will neither open too far nor close up too much and so that its movement will be free throughout. It is well to run it roughly around the diagram to see that this is so before seriously starting in on the measurement. The tracing point is then moved along the diagram

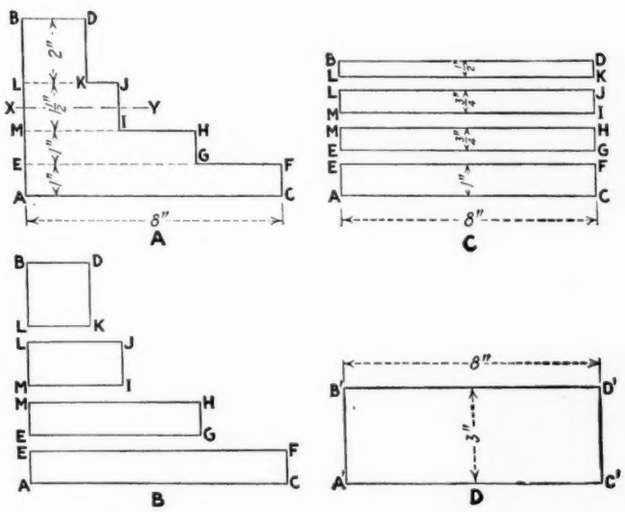


FIG. 2. FINDING EQUIVALENT AREA

clockwise and the outline of the diagram is followed until the tracing point again reaches *A*. The reading shown on the wheel is proportional to the area of the diagram and, when divided by the diagram length, gives the average height in inches. Since the height is proportional to the pressure, depending upon the indicator spring scale, the mean effective pressure is obtained at once by multiplying the height by the spring scale.

For example, suppose the wheel reading is set to zero and after tracing the outline of the diagram the reading is 3.51. This means that the diagram area is 3.51 sq.in. As a precaution the diagram is measured

again, and the reading is now, say, 3.52 while a third reading may give 3.53. The average is, then, 3.52 sq.in. Or instead of setting the wheel to read zero upon starting, we can simply read the wheel scale which, say, shows 1.21. In going around the diagram the wheel registers 4.72, and upon making the second tracing the wheel shows a reading of 8.24, while the

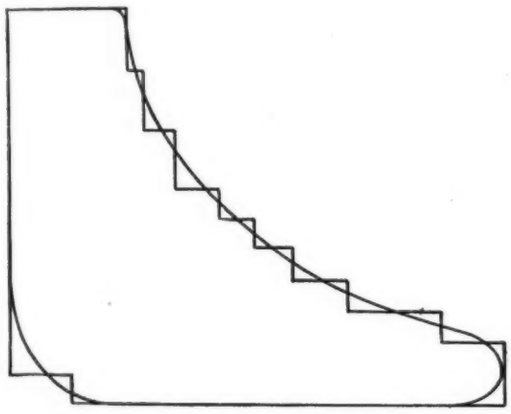


FIG. 3. INDICATOR DIAGRAM AS A SERIES OF RECTANGLES

third tracing gives a final wheel reading of 11.77. The readings for the three tracings are

Tracing 1.	4.72 — 1.21 (original reading)	3.51
Tracing 2.	8.24 — 4.72	3.52
Tracing 3.	11.77 — 8.24	3.53
	3	10.56
Average area, square inches		3.52

If the length of the indicator diagram is 3 in., the average height becomes $3.52 \div 3 = 1.173$ in. Assuming the indicator spring used was a 50 spring (meaning 1 in. height equal to 50 lb. pressure) the mean effective pressure is $50 \times 1.173 = 58.65$ pounds.

Before the planimeter can be used successfully, the method of reading a scale having a vernier must be understood. In Fig. 6 we have a wheel from a planimeter. This wheel is divided into 10 units each of which is divided into ten equal parts. The first units marked 1...4, 5, etc., indicate square inches, while the smaller units of course represent tenths of a sq.in.,

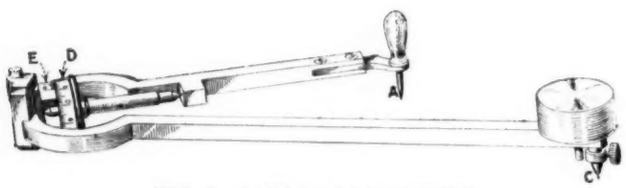


FIG. 4. AMSLER PLANIMETER

being one-tenth as long as the larger scale reading. At one side of the wheel is placed a scale called a vernier, divided into ten equal spaces as shown at the right, the entire scale from 0 to 10 being equal in length to nine of the small units in the wheel or equal to nine-tenths of one of the 1-in. scales. Then the distance on this vernier from 0 to 1 is equal to nine-tenths of the distance *oa*, or *S* on the wheel scale, or $\frac{9}{100}$ of an inch. The distance from 0 to 2 on the vernier must then be $\frac{18}{100}$ of an inch or $\frac{18}{10}$ of the distance *oa*. If the wheel be moved in the direction of the arrow one-tenth of the space *oa*, then the vernier mark 1 will be exactly opposite *b*, for the distance 01 is nine-tenths of *oa* and a wheel movement of one-tenth of *oa* will bring 1 opposite *b*. A travel of two-tenths of *oa* will bring 2 opposite *c*, and a movement equal to nine-tenths the space *oa* will bring 7 opposite 9 on the Vernier. The right-hand drawing shows a wheel reading of 6.1 sq.in. since *a*, corresponding to 0.1, is opposite the vernier index 0, and no mark on the wheel is in line with any mark on the vernier between 0 and 10. If the wheel had traveled so that *b* was opposite to 1 on the vernier, the reading would be 6.11, or since the 6 represents square inches, the reading would be 6.11 sq.in. On the wheel at the left of Fig. 6 the reading is 4.73, since the 3 on the vernier coincides with a line on the wheel. The whole number of square inches is given by the figure on the wheel to the left of the 0 on the vernier, the tenths by the number of whole spaces on the wheel that have passed the 0 mark, the hundredths by the mark on the vernier as *N* that is in line with some mark on the wheel. This can be easily recognized, for the lines on the wheel to either side of it will be one beyond the next mark to the right, and one to the left as at *A* in Fig. 6. The area represented by this latest division is one one-hundredth of a square inch, or a square having sides one-tenth of an inch long. In reading a vernier scale, it is merely necessary to note which one of the vernier marks is exactly opposite a

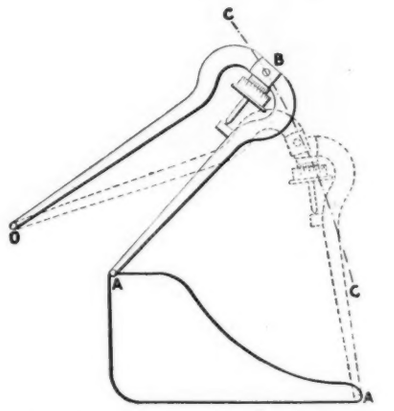


FIG. 5. METHOD OF TRACING DIAGRAM WITH A PLANIMETER

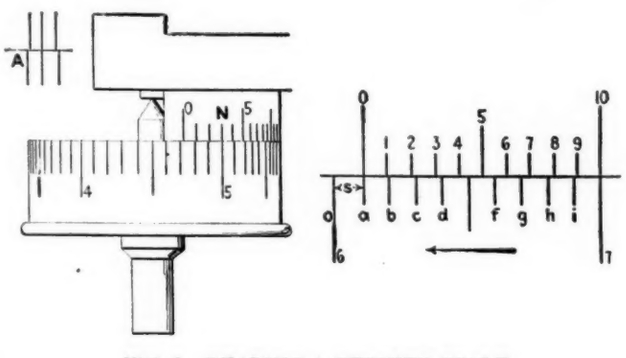


FIG. 6. READING A VERNIER SCALE

wheel scale mark and add this to the wheel reading. In the planimeter only the 0, 5 and 10 are numbered on the vernier, but the intermediate spacings are easily read.

In using the planimeter, a sheet of drawing paper should be held by thumb-tacks to a flat surface. The indicator diagram should be thumb-tacked to this paper.

In tracing the outline of the diagram, the tracing point must follow the indicator pencil marks. If the point is allowed to move away from the pencil tracing.

the areas as registered by the planimeter may be erroneous. If the diagram being measured is small, unless the tracing is carefully done, the m.e.p. may have a serious error.

If cutoff in the engine is early, the expansion line will show a loop as in Fig. 7. In measuring the diagram, the area *abc* represents negative work and must

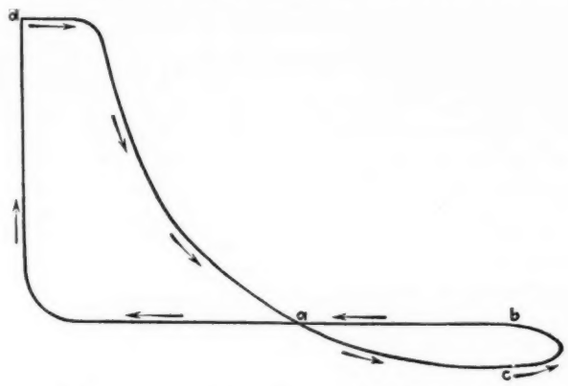


FIG. 7. DIAGRAMS WITH A NEGATIVE LOOP

be deducted from the diagram area to obtain the net area. In tracing the diagram outline, the planimeter tracing point should follow the lines of the diagram in the proper sequence. If the planimeter is started at *d* and moves in the direction of the arrow, the loop should be followed as indicated by the arrows. It will be noticed that when passing over the loop the planimeter wheel will read backward, showing that the area is being subtracted from the diagram area.

After obtaining the diagram area by the planimeter, the mean effective pressure is found by dividing the area in square inches by the length of the diagram in inches. The result is the average height of the diagram which, when multiplied by the spring scale, gives the m.e.p. in pounds per square inch.

The diagram length should be determined with care. By using a triangle, lines just touching the ends of the diagram and perpendicular to the atmospheric line are drawn as indicated in Fig. 8. Frequently, the

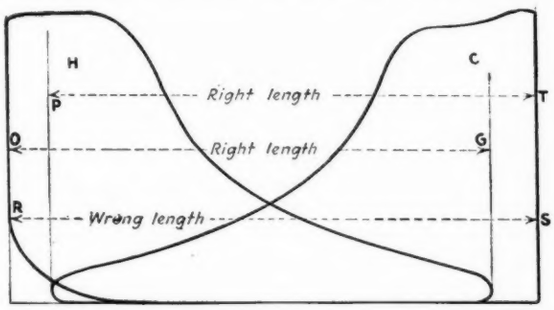


FIG. 8. RIGHT AND WRONG DIAGRAM LENGTHS

diagrams are not in the same position on the paper, and in measuring the lengths in Fig. 8, for the head end diagram, the length *OG* is correct and not *RS;* similarly, for the crank end diagram *PT* is the correct length.

The method of obtaining the mean effective pressure may be expressed as follows:

Rule: *Divide the area as found by the planimeter by the diagram length, and multiply the quotient by the scale of the indicator spring with which the diagram was taken. The product is the mean effective pressure.*

In a planimeter the area of the diagram in square inches is equal to the length of the tracing or measuring area times the circular movement of the wheel. Advantage is taken of this in the design of the Amsler planimeter, Fig. 9. If, for example, the tracing arm from point *A* to the hinge *C* is 4 in., then for the wheel to

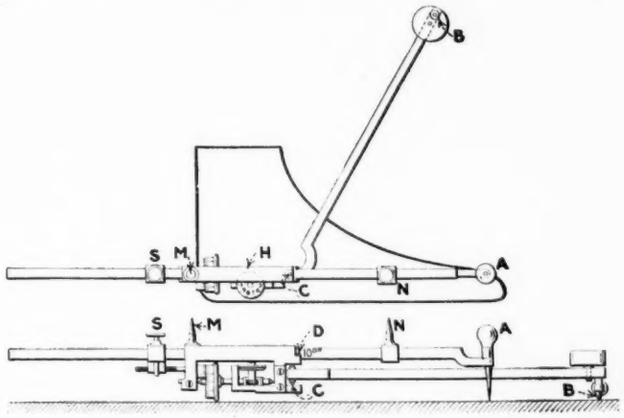


FIG. 9. IMPROVED AMSLER PLANIMETER

indicate 10 sq.in. in one revolution its circumference must be 2.5 in. If the length of the diagram is doubled to 8 in., one revolution of either wheel would give 20 sq.in., or to measure 10 sq.in. the wheel need turn but one-half a revolution. If the arm were 2 in. instead of 4, a complete revolution of the wheel would give 5 sq.in. The movement of the wheel to measure a given area is then proportional to the length of the tracing arm.

In an indicator diagram the mean effective pressure is found by dividing the area by the diagram length. In a diagram of a definite area the m.e.p. will be halved if the diagram length be doubled; if the length is halved, the m.e.p. will be doubled. This means that for a given area the m.e.p. varies inversely as length. Since the wheel travel of the planimeter varies with the length of the tracing arm, it is evident that by making the tracing arm equal to the diagram in length, the wheel travel will vary directly with the m.e.p. and so enable

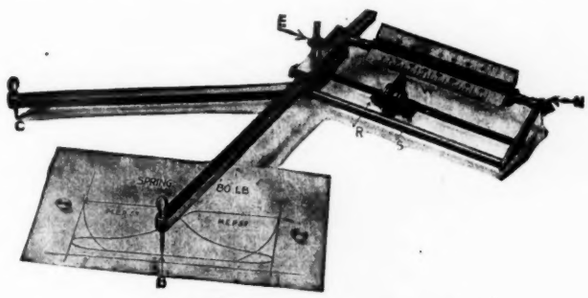


FIG. 10. WILLIS PLANIMETER

the mean height of the diagram to be read directly from the planimeter-wheel scale. This is done in the planimeter Fig. 9 by placing the points *M* and *N* at the extremities of the diagram to be measured, and in this way the tracing arm *AC*, which is equal to *MN*, is made equal to the diagram length. The adjusting screw *S* enables the distance *MN* to be brought up to the exact diagram length. The indications on the wheel scale then will give the mean diagram height. The planimeter wheel is calibrated to read pounds direct if

a 40-lb. indicator spring has been used. If a different spring, say a 50-lb. spring, has been used, the m.e.p. $= \frac{50}{40} \times$ wheel reading.

The Willis planimeter, Fig. 10, although based on the same general principle, is somewhat different in construction. Here the wheel travels lengthwise of the axis

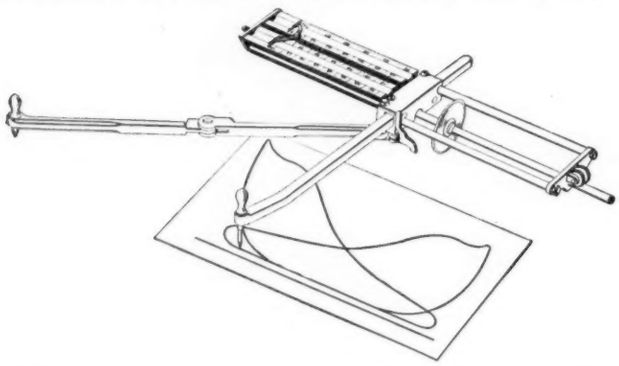


FIG. 11. LIPPINCOTT PLANIMETER WITH TWO SCALES

to give the diagram area. A six-sided rule is provided upon whose faces are scales to correspond to several indicator-spring scales. By turning the rule to bring the proper scale toward the wheel, the m.e.p. is read directly.

Still another planimeter of somewhat similar design is the Lippincott, shown in Fig. 11. Two scale bases are provided, giving a choice of twelve spring scales.

The Coffin averaging instrument, which appears in Fig. 12, reads average heights only and will not read

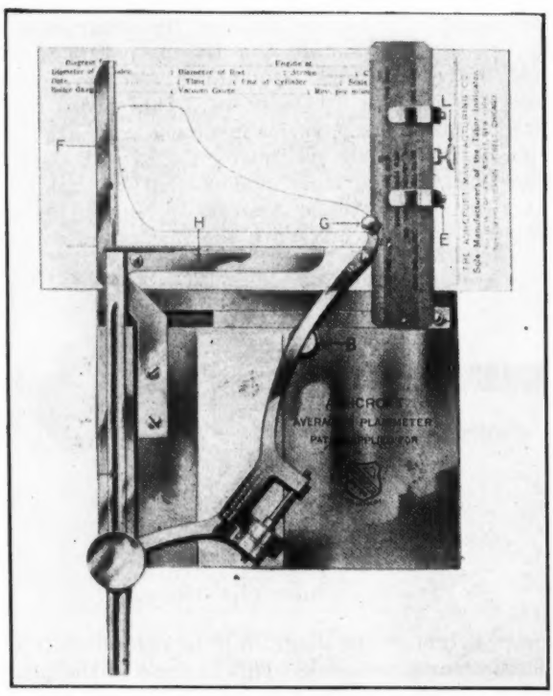
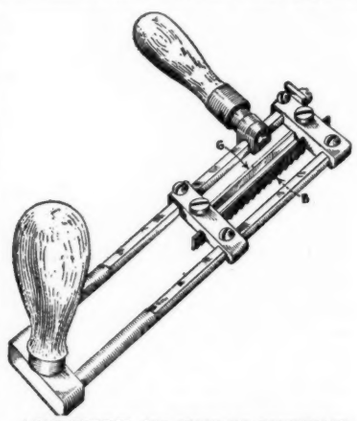


FIG. 12. COFFIN AVERAGING INSTRUMENT

diagram areas. The diagram to be measured is slipped under the clip *F* until the edge of the clip coincides with the end of the diagram. The reading on the wheel is noted and the outline of the diagram followed until the circuit has been completed. The tracing point *G* is then moved up along the scale to a point where the wheel reading is the same as before the diagram was measured. The distance measured from the starting point to this point is the average height of the diagram. By using a suitable scale, this distance is converted into m.e.p. in pounds per square inch.

Tool for Undercutting Mica in Commutators

It has become general practice to undercut the mica in commutators of direct-current machines. Commutator slotting is safe on almost any machine, but certain precautions are necessary in many cases. The U-shaped slot is satisfactory for high-speed machines if greasy dirt can be kept off the commutator. With this type of slot care must be exercised to remove all strips of mica along the edge of the bars. The V-shaped slot is coming into extensive use on high-speed machines and is essential on low-speed equipment, particularly when operating in dirty locations. Where an excessive amount of oil can creep onto the commutator, the V-shaped slot may be given a coat of water- and oil-proof insulating varnish to keep the slot clean.



ASSEMBLY OF UNDERCUTTING TOOL

For undercutting commutator mica, the tools vary from a piece of hacksaw blade held in a handle to expensive motor-driven equipment. To meet the needs for an inexpensive hand tool for undercutting commutator mica, the Martindale Electric Co., Cleveland, Ohio, has developed and placed on the market an equipment known as the Imperial commutator slotting tool, which is shown in the figure. This tool is hand-operated and cuts a V-shaped slot, and the tool's construction is such as to give the operator a clear vision of the work at all times. The blade *B* is reversible so as to cut on either the pull or the push stroke. An adjustable guide *G* rides in the previous slot and prevents the tool from slipping and marring the commutator. Adjusting screws are provided to regulate the depth of the slot, and the clamps are movable to suit different lengths of blades, varying from 1 to 4 in. The equipment makes an excellent holder for hacksaw blades. A great many men are now using hacksaw blades in home-made holders, but these do not provide facilities for regulating the depth of the slot nor do they have guides to ride in the previous slot.

An oil engine is generally left in good working condition by the manufacturer's erectors, but unless the operator is skilled there is danger of misadjustment of the fuel valve. A slight misadjustment of the clearance between the fuel-valve roller and the fuel cam will often allow the fuel to be admitted either too early or too late. In either event the exhaust will be hazy, and in case of late fuel admission the exhaust is often very smoky.

Advantages of the Ring-Oiling Bearing

SUPERIORITY of this method of oiling is pointed out. Instructions are given covering care of bearing and grade of oil to be used. Oil must be replaced at intervals to insure proper lubrication.

By W. F. OSBORNE*

THE plain sleeve type of bearing, oiled from a squirt can, is being rapidly replaced on many kinds of equipment by the ring-oiled bearing, which has many advantages. In the first place it provides a means of continuously furnishing oil to the journal in considerable quantities. With the squirt-can method, a small amount of oil is fed into the bearing at irregular intervals and lubrication depends upon the ability of the oil to stay in the clearance and maintain lubrication until the next oiling period. Certainly, film lubrication cannot be maintained under such conditions, and the less efficient partial or greasy lubrication must exist. Furthermore, the quantity of oil is insufficient to carry away any of the generated heat or any particles of foreign matter that may enter the bearing.

If for any reason the oil supply in the bearing becomes low, the heat due to increased friction will rapidly evaporate the little oil remaining, and the bearing quickly becomes hot. Such bearings should have regular attention, small quantities of oil at frequent intervals, and occasionally should be thoroughly washed out to remove all foreign matter that may have collected.

Proper Grades of Oil

Best results are secured in general with the use of a medium- or heavy-bodied oil, when speeds are low, the viscosity being about 300 seconds Saybolt at 100 deg. F. When loads are light or when speeds are high, the viscosity should be reduced accordingly.

When the ring oiler is used, if it is properly designed, it will carry a flood of oil to the top of the journal, where the oil will be drawn into the clearance space by the pumping action of the journal, and film lubrication will be secured. A suitable ring will carry more oil to the top of the shaft than is actually needed, so that there may be no possibility of an insufficient amount being available to meet the requirements of the bearing. The excess supply of oil will also serve to carry away a certain amount of heat from the upper part of the bearing and lower its temperature.

The value of the ring oiler depends, of course, upon its feeding the oil to a point on the journal where the pressure in the clearance is lower than that outside the bearing, as there is no other force available except gravity to cause the oil to enter. This limits the ring oiler to applications where the load is carried by the shaft and the point of greatest pressure is somewhere on the bottom half of the bearing. The wedge action builds up a pressure in the lower part of the bearing and induces a reduced pressure in the upper part of the bearing. If oil is delivered to the point where the pressure in the bearing is below the outside pressure, it will be drawn into the clearance space, and proper circulation will be secured.

If the load is supported on the bearing cap, as is the case in railway-journal bearings, the ring oiler cannot be used satisfactorily because it will necessarily deliver the oil to the top of the journal where the bearing is under the greatest pressure. The oil will be forced out rather than drawn into the bearing.

In addition to the great advantage of maintaining film lubrication the ring oiler permits the use of a reservoir containing the oil supply; the oil is used over and over again, thereby reducing the consumption. If the reservoir is large enough, the oil will have a chance to come to rest and any bits of metal of foreign material picked up in its course through the bearing will have an opportunity to settle out. The quantity of oil supplied to the journal by the ring oiler is of value also because it tends to wash out any foreign material that might otherwise cause wear if allowed to remain between the shaft and its bearing.

Since the hot oil from the bearing is returned to the reservoir, the only way the journal and bearing can be cooled is by conduction from the bearing and the oil reservoir, unless a circulation of water is maintained through the bearing shell. The cooling of a bearing by conduction is a fairly slow process, depending on a number of factors, such as the specific heat of the oil, its conductivity, the conductivity of the metal, the quantity of oil in the reservoir, etc. It is always advisable to have the reservoir as large as convenient so that the oil will have more time to give up its heat, and the circulation of the oil per unit will not be so rapid. Since it will have more time to cool, the lower temperature reduces the rate of evaporation and deterioration of the oil.

Evaporation of Oil

If a suitable oil is selected, the reservoir needs replenishing often enough only to take care of losses through evaporation and seepage along the shaft. Oil throwers on the shaft will reduce the loss from seepage to a very small amount. On account of the length of time it is used, it is desirable to use a high-grade oil, which will not decompose through exposure to heat and agitation.

Constant circulation through the bearing brings the oil into contact with air and the lighter portions evaporate just as water evaporates at ordinary temperatures, except of course the rate of evaporation is very much lower.

This slow evaporation of the lighter parts of the oil causes the remainder to increase in viscosity, the higher viscosity in turn raising the frictional temperature and further evaporating the oil. It is desirable therefore to use a good grade, which has been properly refined, to have a minimum loss through evaporation at the temperatures at which the bearing is to be operated.

Owing to the gradual evaporation and slow oxidation of the oil in a ring-oiled bearing it should be entirely removed occasionally and replaced with fresh oil after the reservoir and the bearing have been thoroughly cleaned.

Since the lubrication of the journal depends on the capacity of the ring to bring up fresh oil in a sufficient amount, the efficiency of lubrication is influenced by the speed of the journal. If the speeds are too low,

*Supervisor Manufacturing Service, Texas Co.

the ring will not carry up the oil fast enough to maintain a film, and a heavy-bodied oil is necessary, as the film would otherwise be only partially complete and the greater wedging action of the high-viscosity oil is quite an advantage. When speeds are very high, several thousand revolutions per minute, trouble is again experienced through slippage of the ring and the action of centrifugal force in throwing the oil away from the bearing.

Generally speaking, for high-speed bearings, a light-viscosity oil, from 70 to 100 seconds Saybolt, will be satisfactory, and for all medium speeds it is seldom necessary to go above 200 Saybolt at 100 deg. F. Naturally following the laws of fluid friction, the lighter the oil the less will be the internal frictional resistance due to the viscosity of the oil. The viscosity must be carefully proportioned to the speeds, loads, clearances and all other factors in order to secure minimum frictional losses without excessive consumption or dangerously high temperatures.

Q. In estimating the suitability of an oil for use in ring-oiled bearings, what effect does the specific heat have on the conduction of heat from the bearing.

A. There is very little difference in the specific heat of lubricating oils when compared at the same temperature. As the temperature is increased, the specific heat increases quite rapidily, which means that a rise of one degree in the temperature of a bearing operating at 150 deg. F. indicates that there has been a larger increase in frictional resistance than if the bearing had been operating at 100 deg. F. and was raised one degree in temperature. The temperature difference between the bearing and the air influences the rate of conduction of heat, the rate being higher for high temperatures. In other words, it is much harder to heat a bearing from 150 deg. to 151 deg. F. than it is to raise the temperature from 100 deg. to 101 deg. F. This means that a one degree rise in the temperature of a hot bearing is the result of a much greater loss in power due to friction than when the bearing is running much cooler.

Table of Steam Flow in Pipes

Perhaps the most common method of finding the size of steam pipe needed for a given steam flow is to allow a certain velocity in feet per minute. With tables giving the weight of steam per cubic foot at various pressures and the cross-sectional area of pipes of various sizes, one can figure the size of pipe required to allow the given steam flow at the desired velocity. This labor, however, is made unnecessary by the accompanying table reprinted from a pamphlet entitled "Reducing Valves," recently issued by the Atlas Valve Co., of Newark, N. J. This table shows the capacity in pounds per minute, for a velocity of 6,000 ft. per min., of steam pipes ranging in size from ¾-in. to 15-in. at steam pressures from 1 lb. to 250 lb. (gage).

As an example of the use of the table, suppose that it is desired to find the proper size of steam pipe to carry steam at 150 lb. gage pressure to a Corliss engine of 250 i.hp., where the engine has a full-load water rate of 25 lb. of steam per i.hp. hr. The full-load steam consumption will be $250 \times 25 = 6{,}250$ lb. per hour. The flow in pounds per minute will then be $6{,}250 \div 60 = 104.2$. Assuming a steam velocity of 6,000 ft. per min., the table can be used directly. At a pressure of 150 lb. the table shows a flow of 111.9 lb. per min. for a 3-in. pipe. Since this is the closest figure to 104.2, a pipe of this size would come nearest to giving the desired velocity of 6,000 ft. per min.

Suppose, however, that the velocity desired is 8,000 ft. per min., instead of 6,000. It is evident that the pipe need have only $\frac{6{,}000}{8{,}000} = \frac{3}{4}$ the cross-sectional area that it would need for the velocity of 6,000. Another way of putting it is to say that a pipe that will carry $\frac{3}{4} \times 104.2 = 78.2$ lb. of steam per minute at 6,000 ft. per min. would carry 104.2 lb. per min. at 8,000 ft. per min. The nearest figure to 78.2 in the table (opposite 150 lb. pressure) is 72.43, for which the pipe size is 2½-in. A 2½-in. pipe will therefore give a velocity close to the desired 8,000 ft. per minute.

CAPACITIES OF STEAM PIPES IN POUNDS PER MINUTE WITH A STEAM FLOW VELOCITY OF 6000 FEET PER MINUTE

Steam Pressure in Lb. per Sq.In. Gage	Size of Standard Pipe, Inches ¾-In.	1-In.	1¼-In.	1½-In.	2-In.	2½-In.	3-In.
	Weight of Steam in Pounds per Minute						
1	.879	1.426	2.473	3.394	5.541	7.586	12.19
5	1.089	1.766	3.061	4.151	6.859	9.774	15.10
10	1.346	2.183	3.784	5.130	8.477	12.08	18.60
20	1.018	3.002	5.204	7.055	11.65	16.61	25.67
30	2.349	3.809	6.603	8.941	14.79	21.07	32.57
40	2.813	4.603	7.979	10.81	17.87	25.47	39.36
50	3.323	5.389	9.341	12.66	20.92	29.82	46.07
60	3.807	6.174	10.70	14.51	23.97	34.16	52.83
70	4.285	6.949	12.03	16.33	26.98	38.45	59.42
80	4.753	7.708	13.36	18.11	29.93	42.65	65.91
90	5.235	8.490	14.71	19.95	32.97	46.97	72.59
100	5.706	9.254	16.04	21.74	35.93	48.63	79.12
120	6.666	10.81	18.73	25.40	41.98	59.81	92.43
150	8.072	13.09	22.69	30.76	50.83	72.43	111.9
200	10.37	16.82	29.15	39.53	65.32	93.08	143.8
250	12.68	20.57	35.65	42.62	79.82	113.8	175.8
	4-In.	5-In.	6-In.	8-In.	10-In.	12-In.	15-In.
1	21.02	33.03	47.70	81.82	130.2	186.7	301.5
5	26.02	40.89	54.14	101.2	161.1	231.2	373.3
10	32.16	50.52	72.98	125.1	198.5	285.7	461.3
20	44.23	69.50	100.3	172.1	274.0	393.0	634.5
30	56.12	88.19	127.3	218.3	347.6	498.7	805.0
40	67.82	105.9	153.9	263.9	420.1	602.6	972.8
50	79.40	124.7	180.1	309.0	491.8	705.4	1138.
60	90.97	142.9	206.4	354.0	563.5	808.3	1305.
70	102.3	160.8	232.3	398.5	634.0	909.7	1468.
80	113.5	178.4	257.7	442.0	703.5	1009.	1627.
90	125.0	196.4	283.8	486.8	774.9	1111.	1794.
100	136.3	214.2	335.1	530.6	844.6	1211.	1955.
120	159.2	250.2	361.4	619.9	986.6	1414.	2284.
150	192.8	303.0	437.6	750.6	1194.	1713.	2766.
200	247.8	389.4	562.4	964.6	1534.	2201.	3555.
250	303.0	419.0	687.7	1179.	1877.	2692.	4347.

Table copyrighted (1922) by Atlas Valve Co.

Quick Analysis of Coal

For engineering tests of stack losses it is necessary to know the percentage of carbon, hydrogen, oxygen, nitrogen and sulphur in the coal used with reasonable accuracy. Ordinary methods used in the chemical laboratory require skilled operators working for some time with complicated apparatus. S. W. Parr, of the University of Illinois, has proposed a new method for this "ultimate" analysis of coal, by utilization of the result of a fusion of the coal in a bomb with sodium peroxide.

The results of this method of testing can be very quickly obtained and with sufficient accuracy for ordinary engineering tests. The sulphur and the carbon in the coal are determined directly from the fusion. The nitrogen is assumed to be 1.25 per cent, which is an average figure for most American coals. The quantity of hydrogen that contributes to the heat value of the coal is determined by subtracting from the total heat value that portion of the heat which will be contributed by the carbon and sulphur content of the coal. The hydrogen and oxygen in the coal present as hydroxyl radical (OH) is estimated by difference between the total of other constituents and 100. This hydroxyl percentage is, of course, eight-ninths oxygen and one-ninth hydrogen. Thus very simply one can get a good approximation to the chemical constitution of the fuel.

EDITORIALS

The Engineer in Business

THE engineer has been charged with being too "engineery." He is apt to lose himself in the engineering aspects of a situation and not to give full value to the financial and other considerations involved. On the other hand, the business man would often profit by a knowledge, even if somewhat superficial, of the engineering features of enterprises in which he is engaged.

A conference on Commercial Engineering is being held at Pittsburgh, May first and second, under the auspices of the Committee on Commercial Engineering of the United States Bureau of Education. The program comprises:

1. Current Practices in Colleges and Universities Relating to Business Training for Engineers and Engineering Training for Business Men.
2. Co-ordination of College Training with Industrial Demand.
3. Civic and Social Training of the Engineer and Business Man.

This is all in the direction of broadening the engineer into the fullness of an age which his art has made possible and of which it is still the impelling force. It will aid him to direct intelligently as well as to motivate, and to stand out as a citizen as he does as an engineer.

Sluicing Ashes at Hell Gate

DESIGNING and operating engineers will watch with interest the operation of the ash-sluicing system installed in the new Hell Gate Station. This appears to be the first hydraulic ash-removal system installed in a large central station in this country, although ash sluicing has been tried out in several private plants with various degrees of success.

The March 28 issue of *Power* described the installation at the Lake Linden (Michigan) Plant of the Calumet & Hecla Mining Co. This was designed to handle a maximum of fifty tons of ash per day. The system there used is intermittent, the ash hoppers being dumped from time to time into an inclined trough having a pitch of one-quarter inch per foot. Before starting the dumping an eight-inch valve is opened at the head of the trough so that a stream of water, coming out under forty-five pounds pressure, sweeps down its length. So far, operation at Lake Linden has been entirely at low loads, but it is estimated that approximately five thousand gallons of water will be required per ton of ashes when the boiler-plant is operating at full capacity. In this installation the ashes and water flow into a box from which they must be pumped to a distant disposal point. The centrifugal pumps that handle the combined ash and water are specially constructed to increase the life of the parts and make replacement inexpensive.

The system used at Hell Gate differs from this in a number of ways. In the first case the boilers are equipped with clinker grinders so that the ashes, freed from large lumps, are discharged continuously into the sluices. This, of course, requires a steady flow of water. Water nozzles, located at each boiler, act as boosters. These differences in operating conditions perhaps account for the fact that the pitch of one-quarter inch per foot used at Hell Gate is entirely satisfactory, while the same pitch at Lake Linden requires the occasional use of a shovel to keep the ashes in motion. There is no repumping at Hell Gate. The ashes pass directly to pits along the waterfront where they are stored until removed (to barge or motor truck) by a clamshell bucket. When the station is operating at its ultimate capacity of 300,000 kw., the sluicing system may be required to handle as much as 25 tons of ash per hour.

Aside from the fixed charges the cost of pumping water seems to be practically the only expense in operating such a system. A large amount of water is required, so that careful attention must be given to the questions of water supply, pump efficiency and efficient utilization. Until definite figures are available as to the amount of water required per ton of ash at Hell Gate, it will not be possible to make a reliable comparison of this system with other methods of ash removal. At the same time it is significant that ash sluicing was adopted in this newest of large central stations.

Radio in the Control of Power Equipment

JULES VERNE in all his vivid imagining never conjured tales more astounding than the actual facts of the present transmission of radio signals. The ultimate possibilities of the wireless control of electric power circuits and equipment are probably beyond the ability of the electrical engineer to foretell. Although radio has been used for a number of years for the transmission of messages on power systems, when other means had failed, it has remained until recently for other possibilities to be demonstrated.

At the spring convention of the American Institute of Electrical Engineers in Chicago, F. W. Dunmore, of the radio laboratory of the United States Bureau of Standards, described a relay that has been developed to operate on radio signals. Such a device naturally raises a lot of speculation, as the introduction of this relay did at the meeting, as to its application to remote-control switching of power circuits. At present there is a decided tendency toward the application of automatic and remote control to substations and small hydro-electric power plants operating on large systems. In some of these applications there is an opportunity for a higher degree of selective control, without greatly increased cost or further complication than is obtained with the present equipment. Or again, in switching at remote points on long-distance transmission lines, it may be that at no distant future the load dispatcher will be able, by radio signals, either by simply pushing a button or speaking the proper order, to stop and start machines or control switches at remote points on the system.

These accomplishments are not impossible today under favorable circumstances, since it has been demonstrated that vessels on the water can be controlled by wireless. However, the element of reliability and cost enters into the problem. In reliability, present systems of remote and automatic control have been so highly developed that they are not only almost human in their functioning but are far more reliable. In fact one of the chief reasons for changing over to remote and automatic control of electrical equipment has been to eliminate so far as possible the error of the human element. No doubt the radio relay will find a place in limited application in the control of power equipment, but the control of circuits over a wire will undoubtedly prevail for some time.

Meeting New York's Power Demand

ONE kilowatt of installed capacity for every two and three quarters individuals—such is the dependence of the population of New York City upon electricity for production, transportation and convenience. Exclusive of the more or less obsolete plants held in reserve, there is an active installed capacity of over two million kilowatts which includes central stations, electric railways and private plants in the five boroughs. Of this central stations account for over eight hundred thousand kilowatts. New construction and extensions now contemplated will make the total in excess of this figure.

Anticipating and planning to meet the growth in load is one of the ever present problems of the utilities. Moreover, this must be done without over-equipping, for power equipment is expensive and fixed charges must be met. This has led to the group or unit system now so generally employed in power-plant construction.

Commercial light and power in Manhattan is supplied by the Waterside Stations of the New York Edison Company, the Sherman Creek Station of the United Electric Light and Power Company and the Hell Gate Station of the latter company. The bulk of the current at Waterside is generated at twenty-five cycles and supplies the rotary-converter substations which distribute to the Edison three-wire direct-current system. That at Sherman Creek and Hell Gate is generated at both twenty-five and sixty cycles, current at the former frequency tying in with the Edison system and that at the latter frequency supplying the sixty-cycle system of the United Company.

As the city has grown the center of population and the electrical load has moved steadily northward, and at the same time the center of generating capacity has moved in the same direction. The sixty-cycle load has doubled within the past ten years. Increasing continuously, it has at several times, prior to the construction of Hell Gate, come dangerously close to the limiting capacity of the existing generating equipment, in spite of repeated additions to the latter. For example, in 1917 and 1920 the highest peaks could barely have been carried if the largest turbo-generator on the system had been out of commission. In 1918 the margin became so small that the shutting down of a single turbo-generator would have left no margin at the peak load; hence it was necessary to hasten the construction of Hell Gate Station. This new station, the outstanding features of which are simplicity of operation and reliability, will serve as a base load plant and as such may be expected to set a high record of performance.

The Shipping Board Sells Its Diesel Engines

EARLY in the war the Shipping Board contracted for over fifty Diesel engines, the order afterward being cut to one-half the original number. For some reason never fully disclosed, these engines were not installed on the Board's vessels, but have been held in storage while steam machinery of a far lower efficiency was steadily bought and placed in use.

Recently, the Shipping Board and the War Department entered into an arrangement whereby the Engineers Corps takes over twelve of these Diesels at a transfer price of $30,000 per engine, this being all the funds available.

These engines will be installed on four ocean-going dredges of the hopper-bottom type. Electric drive will be used whereby the two propellers will be driven by motors which in turn will receive power from two 900-hp. Diesels direct-connected to generators. The third engine, which will be 360-hp., will drive the dredging pump. The barges were originally designed for steam machinery, but the necessary alterations required for the Diesel-electric drive are now in progress.

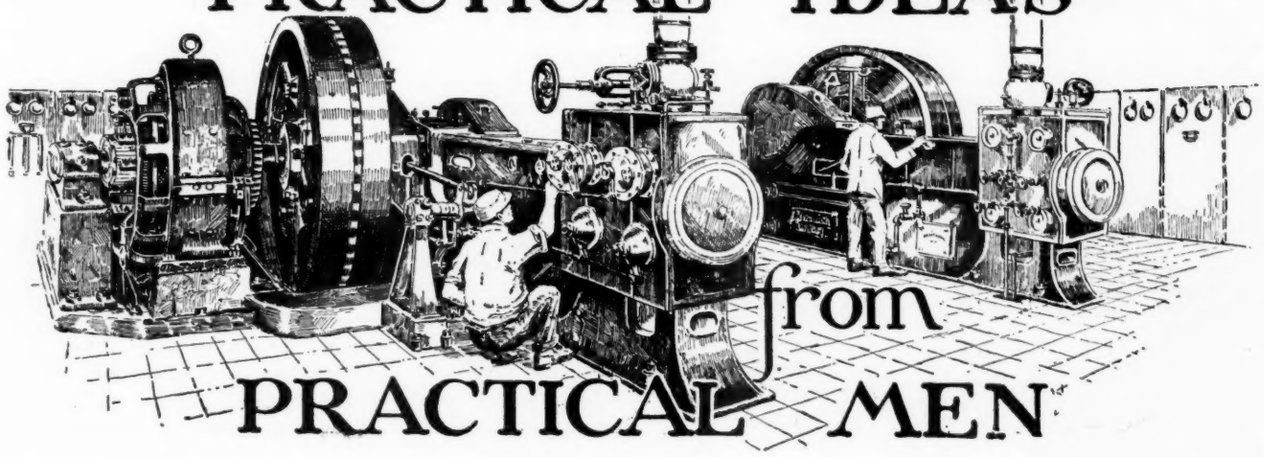
This transfer permits the removal of these engines from storage and will eliminate one of the basic reasons for the private shipowner's unfavorable attitude toward the oil engine. As long as the Board delayed installing these machines, although bought and paid for, in some of the many idle vessels the Diesel engine met with a tremendous amount of resistance from the shipping concerns.

Now that these are out of the way it is to be hoped that more of the new vessels building will install oil engines. The Board has recently taken a step that should do much to encourage the adoption of the oil-engine drive. This is the offer to sell a vessel at a very low price per ton to any shipper who will agree to use Diesel engines. At the same time the Board offers Diesels at about one-half current prices. For tanker service, which takes in a large percentage of the vessels now building it is felt in marine circles that steam machinery is better in the long run. This belief is grounded on the theory that the Diesel will not successfully burn the heavy Mexican oil. On the contrary, this oil can be used if the viscosity is lowered by heating to a point where the oil will flow readily in the piping.

A single carload of coal may change hands as many as twelve times between the mine and the consumer, according to specific observations made by the Federal Trade Commission. Each of the many middlemen naturally takes a little profit for himself, for which the consumer receives nothing but further delay. Of course there must be retail coal dealers, but there need not be an army of middlemen for each shipment. Might not the captains of the coal industry do well to turn some of their attention from shaving labor costs to the task of eliminating parasites from their distribution system?

A boiler inspector recently investigated the explosion of a cast-iron boiler in a theater and found a plumber's wiping cloth, such as is used in wiping lead joints, which had lodged in the water passage, thus preventing the section from receiving water as freely as it should. Some folks certainly have a troublesome habit of leaving their tools around after finishing a job!

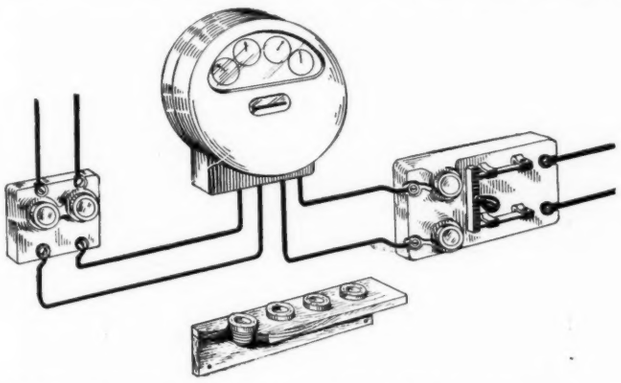
PRACTICAL IDEAS from PRACTICAL MEN



Emergency Fuse Rack Near Panel Board

When a fuse blows in a power or industrial plant and throws it into darkness, it is not only inconvenient but often dangerous for one to go hunting around to find a spare fuse.

This annoyance can be avoided by installing a rack



BLOWN FUSES ARE READILY REPLACED IF SPARES ARE KEPT NEAR THE CUTOUT

as a fuse holder, as shown in the illustration. With spare fuses located close to the cutout, a burned-out fuse may be readily replaced by the light of a single match, and in many cases the match will not be needed.

Brooklyn, N. Y. A. A. LOBROVICK.

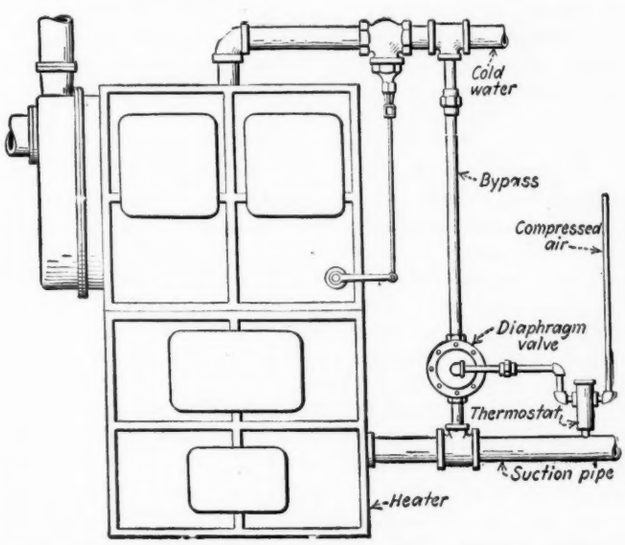
Preventing Feed Pump from Getting Steam-Bound

The outlet from an open feed-water heater should be at least four feet higher than the suction inlet of the feed pump, so as to provide sufficient head to overcome the tendency of the pump to become vapor-bound. In some installations, however, structural restrictions may not permit this arrangement. In the plant of a certain office building the headroom in the space set apart for the heater and feed pumps was so scant that the outlet from the heater had to be set level with the pump inlet. In this case a feed-water temperature of 210 deg. was obtained in the heater, but it was impossible to deliver the water to the boilers at that temperature, as the pumps became vapor-bound.

To overcome the difficulty, the arrangement shown in the illustration was installed. A ¾-in. pipe, fitted with a diaphragm operated valve, was connected between the suction pipe of the pump and the cold feed-water supply from the house tanks to the heater. The diaphragm valve is operated by means of compressed air. A thermostat for controlling the air pressure on the diaphragm was inserted in the suction pipe.

The thermostat is set for a temperature of about 204 deg. When the water flowing through the suction pipe reaches this temperature, the thermostat admits the compressed air to the diaphragm, thus causing the valve to open and allow a stream of cold water to enter the suction pipe. Then, when the temperature of the feed water has dropped a few degrees, the thermostat releases the air from the diaphragm and the valve closes.

This intermittent injection of cold water gives an



ARRANGEMENT OF THERMOSTAT AND VALVE CONNECTIONS FOR CONTROLLING COLD-WATER INJECTION

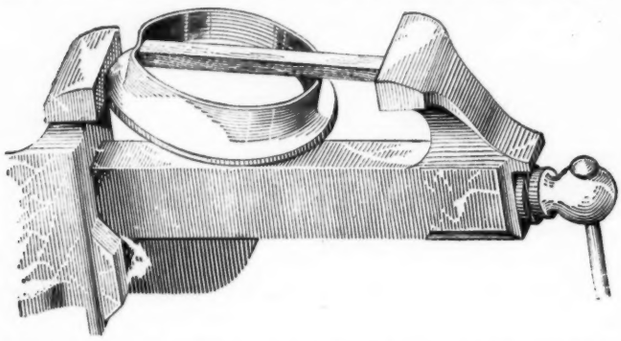
average feed-water temperature in the suction pipe approximating 200 and 205 deg., even though the water flowing from the heater may have a temperature of 210 deg. The device has been in use for about two years and has met the requirements satisfactorily.

St. Louis, Mo. A. J. DIXON.

Truing Up a Bent Glass Rim

The glass holding rims of steam gages are frequently dropped and the thin threaded portion bent out of round, making it impossible to screw it back on the casing. Where one has plenty of tools and time to true them up, this is not much of a task, but when one is in a hurry it is indeed aggravating.

The illustration shows a simple way to force the rims out, and this can be done without removing the glass



WITH AID OF A VISE AND A STICK THE RIM IS QUICKLY TRUED UP

if it has not been broken. The stick should be rounded at the end to the curvature of the rim. It will then push the thin brass and threads back into a true circle. The idea is simple, but sometimes the best of us would not take advantage of its practicality in a hurry to get the rim back in place after a mishap.

Missouri Valley, Iowa. F. W. BENTLEY.

Practical Attachments for Portable CO_2 Recorder

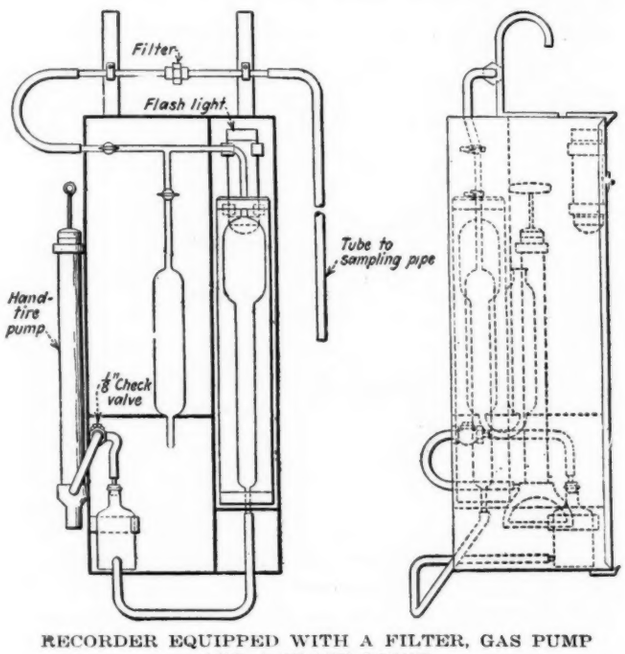
Operators of power plants that are not equipped with automatic CO_2 recorders on each boiler, but get the CO_2 content of the flue gases by means of a portable Orsat, may appreciate the following simple additions that we have made to our apparatus in order to make this daily job a more pleasant one

We first placed two hooks made of ¼ x 1-in. iron bent to fit around the 2-in. soot-blower manifold along the side of the boiler. These hooks were fastened on the top of the case as shown in the illustration, making a rigid support and allowing the apparatus to hang vertical. It also places the apparatus high enough from the floor so that it can be operated comfortably.

Fastened across these hooks so that it does not interfere with the hanging up of the apparatus is a ¼-in. common union with a nipple connected in each side. These nipples extend from the hooks about one inch, so that rubber tubing may be slipped over them. This part of the outfit is the filter and is made by boring ⅜-in. hole in each seat of the union. This leaves about 3/32-in. for the seat. We then cut two rubber washers of ⅞-in. outside diameter and ⅜-in. hole from 1/16-in. sheet rubber packing. Placed between these washers is a piece of very fine-mesh wire screening (about 80 meshes per inch). This is placed inside the union and screwed tight. The filter is then connected in series with the sampling pipe and Orsat.

Next we have taken an ordinary bicycle pump and changed the washer so that it acts as a vacuum instead of a pressure pump. The hose to the pump was discarded and the hole tapped to take a ⅛-in. nipple. The pump is hung on the side of the case by a spring holder in such a way that it can be easily taken off when it is to be used. The connection between the suction of the pump and the check valve is made with a piece of rubber tubing. This valve is fastened to the side of the case just under the shelf that holds the pipette. The other side of the check valve is connected with rubber tubing to the rubber stopper of the leveling bottle. When drawing a sample of gas this stopper is placed in the top of the leveling bottle (the bottle being held by a spring clamp) and the gas is readily drawn through the apparatus by the pump.

In taking samples, it is usually too dark between boilers to use the instrument without some sort of a light by which the scale on the burrette may be read. An extension light run from some convenient socket, or a flash light must be carried to each boiler by the operator. To overcome this, we placed a removable back on our instrument, and in the upper right-hand corner just behind the burrette we have mounted in two spring holders an ordinary flash light (two cell). A small slot is made in the back to receive the button of the flash light, so that it may be turned on or off without removing the back. The inside of the case can be painted



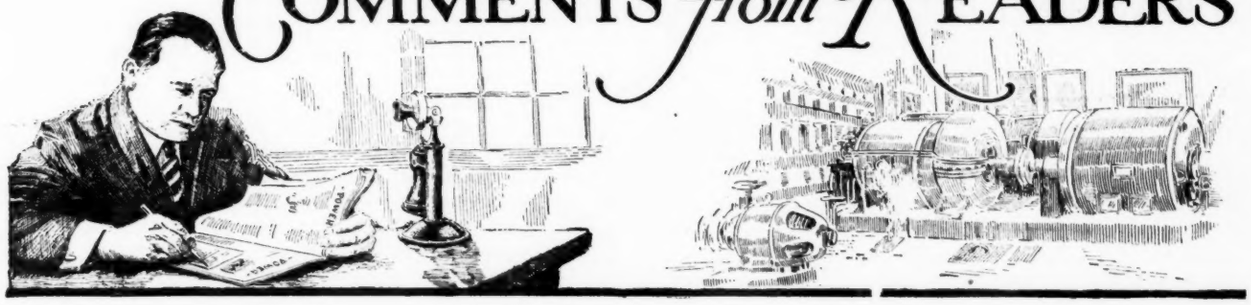
RECORDER EQUIPPED WITH A FILTER, GAS PUMP AND A FLASH LIGHT

with white or aluminum bronze, and when lighted in those dark spots in the boiler room, the burrette can be easily read and the proper level of the caustic solution can be found. C. A. JENNE.

Louisville, Ky.

The color of the exhaust gases leaving the exhaust pipe of the gas or oil engine will give the operator a fairly good idea of the behavior of the engine and will indicate, as a rule, whether the machine is operating economically or whether some of the fuel is blowing out of the exhaust in an unconsumed condition. Operators of oil engines should get in the habit of looking at the exhaust at stated intervals during the day, as it will give them an idea of the engine's behavior, possible to secure in no other way.

COMMENTS from READERS



The Kansas City Air-Receiver Explosion

I was interested in the account, in the Mar. 21 issue, of the air-receiver explosion at the shops of the Kansas City (Mo.) Railways. Particulars that have reached me are incomplete and insufficient to warrant a decision as to the conditions responsible for the accident. The receiver was 5 ft. in diameter and 20 ft. long, and the pressure carried was limited to 110 lb., an unloader being set at that pressure and also a safety valve. Computations, presumably reliable, gave a factor of safety of 4 for the receiver. The compressor which, it was said, was installed ten years ago was actually installed in 1902. It had been completely overhauled three months previous to the accident and had recently passed the routine state inspection.

It is not necessary to know whether the permitted air pressure was in this case exceeded little or much. The compressor would certainly have stalled if worked much higher. The visible results of the accident warrant the assumption that the explosion was not caused by the giving way of the material of the receiver under any steady or gradually increasing pressure.

It is well known and easily understandable that air receivers, when they give way through weakness under increasing internal static pressure, do not explode with such force nor produce such disastrous results as those which follow the explosion of a steam boiler of comparable capacity. In the air receiver there is only the known content of air to escape with an instantly dissipated pressure, while in the case of a boiler explosion the steam content is followed and augmented by an additional mass of steam instantly developed by the high temperature of the body of water.

When an explosive mixture of air and oily vapor is formed and by some means ignited, the increase of pressure is so sudden and so great that no receiver can withstand it, and it is only a waste of time to go into any computations as to strength of materials, etc. Assuming such an explosion to have occurred in this case, investigation should be directed toward the discovery of the conditions that could have produced it, and of this we have little that is directly authoritative in the information that is available.

It is well to bear in mind that only a small proportion of volatilized oil is required to form explosive mixtures, the most powerful combination being about 5 per cent of oil to 95 per cent of air. When this proportion of vaporized oil is present in the air, the mixing occurs very rapidly. Oil of unsuitable character is often used for lubrication, and more frequently the amount used is much in excess of the requirements, so that these explosive mixtures are probably of frequent occurrence, but there is no evidence of their existence except when an explosion occurs. How the "firing off" of the charge is accomplished is still a mystery in too many cases.

That the receiver in this case was filled with an explosive mixture and that the charge was ignited, is in my opinion beyond question. Two witnesses reported having seen a flash of flame and a cloud of smoke burst from the receiver. The scattering of portions of the receiver or the tearing away of any portion of it from the main body could not have resulted from a simple pressure explosion. The destruction of buildings and machinery is additional evidence of the strongest and most indisputable character. The case should not be lodged in our memory as another "compressed-air mystery.' It is a simple case of cause and effect, and the circumstances, if they could be fully known, would no doubt satisfactorily explain the cause of the disaster.

New York City. FRANK RICHARDS.

Pressure and Temperature for Fuel Oils

I noticed the inquiry of F. J. Herbert, in the April 4 issue, relative to the proper pressure and temperature to use in firing fuel oil, using steam for atomization. These factors depend almost entirely on the gravity of the oil and the temperature to which it is heated prior to delivery to the burners. The hotter the oil the lower will be its viscosity and the higher its fluidity, and hence a lower pressure can be used to handle it.

In general practice with Mexican oils the average gravity is 14 to 16 deg. Baumé, and the pressure at which it is delivered to the burner is from 90 to 110 lb., with a temperature of 160 to 200 deg. F. The pressure should be kept constant and steady in order to insure uniform oil flow and to secure the best atomization. This can best be obtained by a properly arranged pumping system and careful attendance, and also in the use of a relief valve on the pump discharge, or an auxiliary standpipe into which the oil is pumped prior to its flow to the burners. For the average plant requirements the latter is perhaps the simplest type of equipment, but it may not meet insurance regulations, owing to the principle of gravity flow being involved. Should pumping be stopped and the master oil valve between the standpipe and burner line leak or be left open, there would be a chance of flooding the furnace with the oil contained in the standpipe. In using a standpipe the operator should maintain a level in the tank sufficient to keep the pipe filled and the pressure on the line constant.

As to the proper temperature to carry the fuel oil, this will depend almost entirely on its gravity and viscosity. As a general rule the heating temperature for

fuel oils should be just sufficient to raise them to the desired fluidity. Too high a temperature I have found is liable to cause pulsation and unsteady burning of the oil. On the other hand, if the temperature is too low, there will be an excessive load put upon the oil pump to force the sluggish oil through the lines, and this oil, being not completely atomized, will be likely to cause smoke and perhaps flaming in the uptakes. I have found it to take a good deal of experience in judging conditions pertinent to combustion to determine properly the correct temperature to which the oil should be heated. In marine practice from 10 to 15 deg. Engler has been considered as the proper viscosity in order to fire the oil most efficiently. The temperature to which a 14-16 Baumé gravity fuel oil would have to be raised in order to reduce it to such a viscosity would probably be in the neighborhood of 200 deg. F.

With regard to how close to the flash point a fuel oil should be carried, in marine practice it is a general rule never to heat the oil above the flash point. This, of course, is a matter of safety and to comply with insurance regulations. In stationary practice, however, while it is considered advisable to follow this same rule, yet it is frequently found necessary to heat an oil above its flash point in order to pump it. This would be the case with certain of the heavier Mexican crudes, of 10 plus, Baumé gravity, which have a flash point varying all the way from room temperature up to 150 deg. F. I recently came across a case exemplifying this point, where a ship was burning heavy Mexican crudes with considerable difficulty due to the low flash point of the oil, and at such a low temperature that the fuel pumps could hardly handle it. They were also experiencing considerable trouble with clogged burners.

An oil can be heated above its flash point with comparatively little danger if the piping and connections are kept free from leaks and the oil is not allowed to drip or accumulate where a flash might occur. However, it will be playing safe never to heat above the flash point, if possible, and when you purchase your fuel, insist that the dealer furnish you with a statement of its flash point, Baumé gravity and, if possible, to what temperature the oil should be heated in order to reduce its viscosity to about 10 to 15 deg. Engler. Then you can operate without guesswork. ALLEN F. BREWER.

Port Arthur, Tex.

The majority of oil burners are so constructed that the steam and the oil meet inside of the nozzle. Where a burner of this style is used, the best results will be obtained by having the oil pressure and the steam pressure about equal, or the oil pressure a little in excess of the steam pressure. Otherwise, where the steam pressure is greatest, it would have a tendency to work against the flow of oil on account of both coming together inside the nozzle.

Some burners are made for operating with a gravity pressure of 6 or 8 lb. This pressure is obtained by elevating the fuel tanks. However, this does not comply with the fire underwriters regulations, and in most cases the pressure is supplied by using two pumps, one of which is reserved for emergency service.

The desired pressure is obtained by connecting a relief valve between the discharge or the suction line. This valve is set to give a pressure corresponding to the maximum boiler pressure.

With regard to the temperature, it is unusual to reach a temperature which would be considered dangerous. With the standard installation the fuel oil is heated from the exhaust steam passing through a coil in a small cylindrical tank used as a receptacle for the oil before it passes into the pump, and the temperature obtained from this method is about 150 deg., which is satisfactory for most oils. J. C. COLLIGAN.

Dallas, Tex.

Mr. Herbert does not tell us what type of burner he is using. However, a statement of the conditions under which the writer is burning fuel oil and the temperature and pressure carried may be of interest.

Our burners are steam atomizers and of the type known as outside mixers; in other words, the steam and oil do not mix until they have been discharged from their respective orifices in the burner, the steam being discharged horizontally into the furnace in a flat fan-shaped jet, while the oil is discharged vertically just in front of the steam orifice.

The oil is carried in the main supply pipe at a pressure of about 15 lb., and is throttled at the burner to give the proper rate of discharge, which controls the quantity burned. The burner steam is carried at a pressure of about 100 lb. and is also throttled at the burner to give the proper flame length and degree of atomization. The oil is heated in the service tank to about 175 deg. F. and is then pumped directly to the burners through secondary heaters, which raise the temperature to about 260 to 275 deg. F.

There is a slight drop in temperature between the heaters and the burners, but we are doubtless burning the oil at from 240 to 260 deg. F., and we have no trouble in maintaining good conditions at these temperatures.

We consider that there are two things to be gained from carrying a high fuel temperature—less steam is required for atomization and the hydrogen loss is lower. Since this loss is proportional to the difference in temperature of the fuel and the temperature of the flue gases, the nearer these can be brought together the smaller the hydrogen loss becomes.

The oil runs from 14 to 16 deg. Baumé, has a flash point of 190 to 210 deg. F., and contains about 11 per cent hydrogen. C. B. HUDSON.

Plymouth, Mass.

Burning Low-Ash Coal

Mr. Flagg's experience (described in the Feb. 28 issue) with the low-ash coal burning out the stoker grates was read with interest, and from my own experience with stokers of this type I am inclined to think that the stoker itself was partly the cause of the trouble. From the analysis given, the coal is apparently one of the best grades from the New River field, but the fusing temperature of the ash is low, and the coal would probably clinker badly under any conditions, although for hand firing the accumulation of clinker with such a low ash content would be too slow to cause any particular trouble, it being well distributed over the grates.

With an overfeed stoker of this type, however, the ash is all worked down to the lower part of the stoker, where the coke in process of burning is broken up so as to take full advantage of the air supply, besides being exposed to the radiation of the bridge wall, so that the ash is accumulating in the hottest part of the fire, where the temperature is probably high enough to fuse it to the grate bars. This is corroborated by thermocouple

readings which show in practically all cases the highest temperature at the couple nearest the bottom of the grate.

A further contributing cause is deficient air supply below the grates. This produces higher fuel-bed temperatures, particularly in the lower part of the fire. This is a characteristic of this type of stoker, as the steam-jet arrangement is inefficient as a blower and considerable secondary air over the fire is required. In other instances there developed serious clinkering of ash from anthracite, which is comparatively infusible. This clinker burned out the furnace bars rapidly and was finally cured by carrying water in the ashpits to cool the bars by radiation and turning the exhaust steam of the stoker engines into the ashpit through a perforated pipe near the clinker zone to cool the clinker and prevent it sticking to the bars.

I do not think the results obtained by mixing siftings with the coal conclusive evidence that a somewhat higher ash coal of the same fusing temperature would not have given equal trouble, as the fire obtained when feeding a mixture of siftings is entirely different. The siftings act as so much dead sand and prevent the fire from coking, thus forming a porous fuel bed such as is necessary for high CO_2 and high capacity. The evidence would be more conclusive if CO_2 readings and steam-flow meter figures had been obtained for the period of feeding the siftings.

I also disagree with the editorial comment on the disadvantages of ashless coal, for I believe this could be burned satisfactorily on overfeed stokers if the air openings were properly arranged. While the Deville furnace corresponds more nearly to a hand-fired flat grate, yet practically ashless fuel—electric-light carbons—can be burned in it to generate temperatures in the fuel bed in excess of 3,200 deg. F., melting every sample of firebrick submitted and flowing the sand used to support the seger cones to a clear glass. This furnace can be operated for weeks at a time without trouble from the grates.

It is now practically a settled question that the satisfactory burning of small anthracite depends on the correct arrangement of the air space in the grates to produce the proper distribution of air to the fuel bed. A soft-coal fire is less affected by poorly designed grates, yet on some designs with a readily fusible ash, or when operated at high rates of combustion, this limitation is evident for soft coal as well. H. D. FISHER.

New Haven, Conn.

Why Do the Piston Rings Break?

In response to the request of Mr. Hilliary in the Feb. 28 issue, as to the cause of piston rings breaking, I offer the following suggestions:

If his engine is fitted with the proper size rings as to width and thickness, whether of the eccentric design or not, and the cylinder walls are in good condition, he may have neglected to remove the sharp knife-edge corners of the rings which come in contact with the cylinder walls. If this has not been done, there will be a lack of lubrication, as the corners of the rings will shave the lubrication off and the very best oils will fail to give the desired results.

Another important thing to consider with an engine of this kind is the point at which the oil enters the steam pipe. It will be found to give more efficient results if tapped into the line about four feet ahead of the throttle, and the pipe should enter to the center of the steam line. This allows the steam to surround the oil thoroughly and it is atomized before it reaches the cylinder.

It is a common practice to fit a plain or eccentric ring with a pin to prevent it from turning, and thereby eliminate any chance of the lap portion of the ring coming in contact with the valve ports, as this is a frequent cause of broken piston rings.

For cylinders of this size piston rings are generally turned $\frac{1}{4}$ in. larger in diameter than the cylinder before they are cut, and then enough is cut out in the lap to allow the rings to fit the cylinder.

The thickness of the ring is usually made $\frac{1}{30}$ of the diameter of the cylinder plus $\frac{1}{8}$ in. and the width equal to the thickness plus $\frac{1}{8}$ in. For an eccentric ring the mean thickness may be the same as for a ring of uniform thickness and the minimum thickness equal to two-thirds the maximum.

However, in this case, if these rings have been properly made, I am of the opinion that it is only a lubricating trouble or the lap portion of the rings working around until they come in contact with the valve ports, which causes them to break. H. W. ROSE.

Victoria, Tex.

Why Not Use a Slide Rule?

In your editorial in the April 18 issue of *Power* you refer to the still prevalent idea that a slide rule is not accurate. I think that many people also imagine that the error in using a slide rule is variable since the divisions are so much greater at one end than at the other.

The writer has found from many years use that a slide rule is decidedly more accurate than is required in the majority of engineering computations. Also most engineering problems require the use at some point in the cycle of one or more variable constants based on experience. Even if the work is done with the exactness of "long-hand" arithmetic, the results may in fact be in error by an amount many times in excess of that which would be caused by the use of a slide rule.

It is easy to prove mathematically that the percentage error of a slide rule due to an error of any definite distance in reading is the same for all parts of the rule. In order to obtain an idea of just what the error of a slide rule really is, the writer several years ago took a list of three-figure numbers and multiplied them on a ten-inch slide rule and on a multiplying machine. The greatest error was 0.15 of one per cent and the least error 0. The average of all the errors was 0.06 of one per cent. The plus and minus errors were almost equal.

From the results obtained, it is certain that the probable error for any one operation should not exceed one-tenth of one per cent and that for a series of operations the total error would not exceed one-fifth of one per cent due to the balancing of the plus and minus errors. An error of this magnitude is much less than the required accuracy for most engineering work.

Of course the personality of the observer enters to a large extent into any determination of this character, and other observers would probably obtain results either greater or less than those given herein; but the difference should not exceed 25 per cent.

Brooklyn, New York. W. L. DURAND.

QUESTIONS AND ANSWERS

Ratio of Steam to Water Space of Boiler

What should be the ratio of steam space to water space of a return-tubular boiler? A. S. B.

A ratio of steam space to water space of one-half to one-third is found to be satisfactory in practice. Smaller water volume requires more careful attendance to prevent irregularity of the steam pressure, and on the other hand, a large body of water steadies the operation of generating steam by serving as a storage reservoir of heat for meeting sudden demands.

Orifice to Discharge Given Quantity of Compressed Air

What should be the size of orifice in thin plate to discharge to the atmosphere 1,500 cu.ft. of free air per minute from a gage pressure of 40 lb. per sq.in. and temperature of 140 deg. F.? C. M.

For practical purposes the flow of air W in pounds per second, through a round, sharp-edged orifice, or orifice in thin plate, where the initial or higher pressure is more than twice the pressure on the discharge side of the orifice, may be calculated by Fleigner's formula,

$$W = 0.53 \times a \frac{p}{\sqrt{T}}$$

where a is the area of the orifice in square inches, T is the absolute temperature in degrees F. at the absolute pressure p pounds per square inch in the reservoir or high-pressure side of the orifice.

Assuming the weight of free air to be 0.076 lb. per cu.ft., a discharge of 1,500 cu.ft. of free air per minute would be equal to the discharge of $1{,}500 \div 60 \times 0.076 = 1.9$ lb. of air per second. The gage pressure of 40 lb. per sq.in. is equal to $40 + 14.7 = 54.7$ lb. per sq.in. absolute, and the temperature of 140 deg. F. $= 140 + 460 = 600$ deg. absolute. Hence, by substituting the formula becomes

$$1.9 = 0.53 \times a \frac{54.7}{\sqrt{600}}, \text{ or } a = 1.605336 \text{ sq.in.};$$

and the diameter of a circular aperture of that area would be $\sqrt{1.605336 \div 0.7854} = 1.43$ in.

Setting Valve of Single-Valve Automatic Engine

How can the valve be set of a single-valve automatic shaft-governed engine? W. G. S.

If the shaft governor is keyed to the shaft or the correct position is known from a setscrew or other mark on the shaft, when the governor is set to the proper position the valve setting consists in simply adjusting the length of the valve stem to obtain the desired equalization of the leads and cutoffs. When the position of the governor wheel must be found, place the piston on a dead center, turn the governor wheel in various positions, and moving the weights in and out, find the position of the wheel where there is no movement to the valve.

With the governor wheel properly set on the shaft, place the engine on the head dead center and with the weights blocked out to the extreme position, the valve should be just on the point of opening or the length of the valve stem should be adjusted to obtain that position of the valve. Then allow the weights to be moved inward and note whether the valve is moved. If it is moved, the engine has a variable lead and the valve setting is completed. If the valve is not moved, the lead is constant and in that case adjust the valve stem to obtain about $\frac{1}{16}$-in lead. Then turn the engine to the crank-end dead center and if the crank end is found to have less lead than the head end, the valve stem should be readjusted to decrease the head-end lead. Next block out the governor to the average running position and note if the cutoffs are equal. If not alike, they can be more nearly equalized by adjusting the length of the valve stem. But this adjustment is at the expense of changing the leads, and equalization of the cutoffs must not be carried so far as not to obtain some lead for both ends.

Effect of Heating Value of Fuel on on Gas-Engine Power

Is it possible to calculate in advance the horsepower which a gas engine will develop with a change in the heating value of the gas? W. L. M.

If the heat liberated by combustion is H B.t.u. per lb. of the air and gas charge and the volume of 1 lb. of this charge is V_1 at the beginning of compression, then the heat liberated per cubic foot of piston-stroke volume is equal to $\frac{HJ}{V_1}$ ft.-lb. when J is the Joule, the mechanical equivalent of 1 B.t.u., that is, 778 ft.-lb. If the cylinder is 1 sq.ft. in area and 1 ft. in stroke, the mean effective pressure in pounds per square foot is $\frac{EHJ}{V_1}$ when E = thermal efficiency of the engine. But in a gas engine $E = 1 - R^{1-n}$ when R = ratio of compression and n = ratio of specific heat at constant pressure and constant volume. Then $\frac{EHJ}{V_1} = \frac{HJ\ (1 - R^{1-n})}{V_1}$ = mean effective pressure per square foot. The value of R is constant, so that the m.e.p. and the horsepower varies with H, the heat content of the gas. Knowing the horsepower of the engine using a gas of given heat value, the horsepower when using a different gas is directly as the ratio of the heat values of the gases provided the same volumes of air and gas are used.

ost Motion of Pump Valve Gear

How is the pause obtained at the end of stroke of a direct duplex steam pump? R. D. N.

The pause is obtained by valve-rod clearance, commonly called "lost motion," which is obtained in various ways. Fig. 1 shows how the clearance usually is provided on small pumps. A valve rod nut *a* is placed on the rod *b* inside of the steam chest, the nut being thinner than the space *c* between projections on the top of the valve. Either the diameter of the nut is made large enough to prevent its turning on the rod and adjustment is made by turning the valve rod, or jamb nuts are used. In this design the total lost motion is fixed and the lost motion *J* at either end, cannot be changed except by use of a nut or jamb nuts of different thickness. In Fig. 2 the lost motion is adjustable both in amount and distance *J* at either side by changing

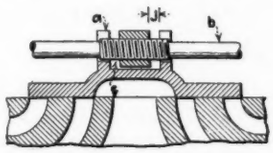


Fig.1, Inside Fixed Lost Motion

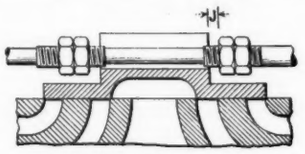


Fig.2, Inside Adjustable Lost Motion

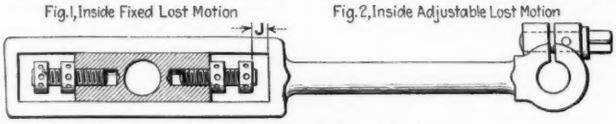


Fig.3, Outside Adjustable Lost Motion

the position of the jamb nuts on the rod on each side of the valve, although the pump must first be stopped and the steam-chest cover removed.

On large pumping engines that are operated by skilled attendants, the clearance is provided in an outside adjustable lost-motion link, Fig. 3, in the train of connections between the valve and its rocker. One end of the link is slotted for carrying a sliding block, shown in cross-section, and the lost motion *J* at either end of the block, is readily adjusted by tappets secured by check nuts, by means of which the lost motion for either end of the valve can be modified while the pumping engine is running.

Operating Three-Phase Alternators Single-Phase

Would there be any objection to operating a standard three-phase alternator to supply a single-phase load? I have been told that serious heating will be produced in the machine. If this is the case, what causes the heating? M. E. W.

One of the most serious objections to operating the machine single-phase is the heating of the rotor. Unless the rotor is laminated, it will probably be impossible to operate the machine single-phase except at a considerably reduced load. When the machine is operating on a three-phase load, the revolving magnetic field of the stator for a given load is constant in value and revolves in synchronism with the polepiece; consequently, the armature reaction between the two fields is constant. In a single-phase machine the magnetic field due to the armature current is pulsating, consequently this field causes a pulsating flux to be set up in the field poles at double the frequency of the machine. Therefore there would be heavy losses in the field poles, corresponding to twice the frequency of the machine. This effect can be overcome in two ways—by laminating the field poles or by the use of a damping winding in the pole faces arranged so as to cut down the pulsating effects of the armature current. In some three-phase machines designed to supply a single-phase load both laminated polepieces and a heavy damping winding are used.

Economy of Increasing Back Pressure for Rise of Feed Water Temperature

What determines the economical limit for raising the back pressure on a non-condensing engine for increasing the temperature of feed water obtained with a closed exhaust-steam feed-water heater? T. M. C.

For the same load on the engine and same initial pressure the limit is reached when the additional heat needed for generation of the greater amount of steam required by the engine, for overcoming the back pressure, is equal to the additional heat obtained out of the exhaust for the feed water.

For the development of the same power, each pound increase of the back pressure will require the engine to be supplied with as much more steam as though the load had been increased to require the same increase of the m.e.p.

For a few pounds variation of the m.e.p., and same back pressure, it may be assumed that the water rate or an engine per m.e.p. or per horsepower is constant, and the additional steam used per pound increase of the back pressure may be considered to be identical with the steam consumption per pound of the original m.e.p.

As an example, suppose the steam is generated at the pressure of 100 lb. gage, or 115 lb. per sq.in. absolute; feed-water temperature, 180 deg. F.; m.e.p. of the engine, 40 lb. per sq.in.; horsepower constant, 6; steam consumption per hp.-hour, 25 lb.; then as each pound of steam at 115 lb. absolute contains 1,188.8 B.t.u. above 32 deg. F. and as the steam consumption is (40 × 6 × 25) pounds per hour, the heat required per pound of feed water as supplied to the boiler would be 1,188.8 + 32 — 180 = 1,040.8 B.t.u., and the total B.t.u. supplied to the boiler for steam furnished to the engine would be 1,040.8 × 40 × 6 × 25 = 6,244,800 B.t.u. per hour. If by increasing the average back pressure 1 lb., the feed water temperature would be raised to 185 deg. F., then for each pound of steam generated the boiler would have to supply 1,188.8 + 32 — 185 = 1,035.8 B.t.u. and therefore the total B.t.u. supplied per hour to the engine would be 1,035.8 × (40 + 1) × 6 × 25 = 6,370,170 B.t.u. per hour.

Under the conditions given, for the same load on the engine the increase of 1 lb. average back pressure for increase of 5 deg. F. temperature of the feed water would require the consumption of (6,370,170 — 6,244,800) × 100 ÷ 6,244,800 = about 2 per cent more fuel.

If the feed-water temperature could be increased from 180 deg. F. to 200 deg. F. for 1 lb. increase of the average back pressure, the boiler would have to supply (1,188.8 + 32 — 210) × (40 + 1) × 6 × 25 = 6,216,420 B.t.u. per hour, which would amount to a saving of (6,244,800 — 6,216,420) × 100 ÷ 6,244,800 = about one-half of one per cent.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

The Electrically Operated Refrigerating Plant*

By H. J. MacIntire

THE last five years has seen a remarkable advance in the use of electricity in ice-making plants, and it is worthy of the serious study of everyone interested in the manufacture of ice and other applications of refrigeration. The main reasons for the change are economical ones —in the lower cost of power, the increased cost of labor and the lack of surety that either coal or labor would be available throughout the operating season.

On the other hand, electric operation implies central-station power, which, except in long-distance transmission, means very nearly 100 per cent continuity of operation. With central power, the units being large, the investment in auxiliaries being very liberal and the best operating talent being available, the generation of power is very efficient, so that at the rate of about two cents per kilowatt-hour and 85 per cent of the power delivered to the ice plant, the electrically operated plant gives 15 to 28 tons of ice per ton of coal—results that are extremely difficult to approach with usual operation, using any other form of prime mover.

The drive may be by leather belt or chain, through gears or by means of direct connection. The motor may be direct-current (compound wound), squirrel-cage or slip-ring induction, or the synchronous-motor type, and on account of the large air gap the only satisfactory alternating-current direct connection is by means of the synchronous motor. The turbo-gear is successful for certain installations, but it increases the first cost and is about as large as the motor itself.

The slip-ring type of motor (variable-speed) has about the same power consumption at all speeds. In both squirrel-cage and the slip-ring type of motor the power factor and the efficiency are small at ¾ and ½ loads. The voltage on the line must be kept up to normal for proper results.

Choosing the Kind of Motor

In choosing motors, then, the problem boils down to the following:

For 25-hp. or less the squirrel-cage motor is used.

For 25 to 75-hp. use the slip-ring type, belt-driven.

For 100-hp. and over use the synchronous motor direct-connected.

In the case of the synchronous motor there are a few points worthy of special attention. This motor has the ability of correcting the power factor and even of acting as a condenser when the field is overexcited. The central station desires such a load and will give a preferance to industries using synchronous motors. Under these conditions, and by limiting the use of power in the winter months, it is possible to get very acceptable terms, even below the total cost of manufacture of the electric current. In general, then, rates of about one cent per kw.-hr. are possible for off-peak contracts.

Variable Capacity Convenient

The use of the synchronous motor means uniform speed, and therefore, uniform tonnage with the same operating conditions. Ice making does not usually require variable speed, but it is convenient at times to vary the capacity of the plant. As the synchronous motor implies constant speed, it is necessary to vary the capacity of the compressor independently. This is done satisfactorily by means of clearance pockets, a device by the use of which the clearance may be conveniently increased by the operator during the operation of the machine. Contrary to an old accepted notion, clearance does not appreciably increase the power required per ton of refrigeration. Of course the capacity is affected, owing to the reduction of the volumetric efficiency of the compressor, but neglecting friction the expansion of the gas in the clearance space is equal to the work done by the piston during compression of that clearance gas.

Satisfactory comparisons of the costs of various designs of ice plants are hard to obtain. However, it is very evident that the electric drive requires considerably less first cost than does the steam engine or the internal-combustion engine. The cost of operation, of course, depends on local conditions, and whether the electric installations are desirable depends on the cost of power, of fuel, labor, and the proximity to the labor market. By the last is meant the ease with which it is possible to get satisfactory engineers and firemen. As a general thing, electric power varies from one cent to two or three cents per kilowatt-hour and the cost of ice in Chicago in 1916 was reported to be about $1.20 for electric power and about $1.50 for steam operation. As compared with steam, there are no boilers, engines or maintenance of same, no smoke, ashes or dirt, and less space is required. Most particularly, the power used can be measured easily and accurately.

*Extract of address before the Wisconsin-Illinois Ice Dealers Association, Peoria, Ill., March 1, 1922.

Coal Strike Progressing; Demand Still Light

As the coal strike continues, with the miners gaining rather than losing ground, the lack of public interest in the matter and the insufficient demand for the output of the non-union mines continue as in the earlier part of the strike. Some interest has been shown, however, by the proposition of a number of plans for settling the difficulty through Government intervention, several such projects having been put before Congress.

Nelson P. Gaskill, chairman of the Federal Trade Commission, appeared before the House Labor Committee and urged passage of legislation under which the Government would be a third party to a forced agreement between the coal operators and the miners regulating the production and distribution of coal. He said that "bogus independent operators" and faked sales are mostly responsible for exorbitant prices of coal to the consumer.

A less drastic suggestion was made by H. A. Garfield, former United States Fuel Administrator, at a recent public dinner in New York City. Under his plan there would be two government advisory commissions—a bituminous and an anthracite commission—which would have no authority except to gather facts about the coal industry. These statistics would then be submitted to the President, and any action taken by the Government would have to be authorized by Congress. This was approved by Phillip Murray, international vice president of the United Mine Workers, who suggested also that before the establishment of permanent commissions, the present difficulty should be settled by Congressional action.

Representative Bland, of Indiana, wants a fact-finding commission of ten members—four Government officials and two representatives each of the operators, the miners and the public. This body would be given full power to require the attendance of witnesses and the production of papers.

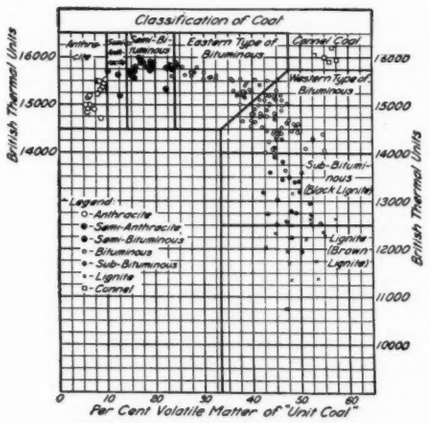
The Colorado River Commission will reassemble late in July or early in August, and will then reach some real conclusions as to the best method of developing the river, according to Secretary Hoover, chairman of the Commission. "There is a sad lack of understanding of even the most fundamental engineering facts in the relation of the upper and lower basins," said Mr. Hoover. The difficulty lies in the fact that the river must be developed as a unit, and not in different parts by independent parties, and therefore the conflicting interests of the several states involved must first be settled.

A new 30,000-kw. generator is to be installed in the Philadelphia Electric Co.'s plant on the Delaware River, at Beach and Palmer Sts., to take care of new business. This will give the plant a total capacity of 90,000 kw. Stone & Webster have been awarded the contract for the construction of the preliminary foundations.

New Classification of Coal Proposed

S. W. Parr, of the University of Illinois, has devised a new basis for classifying coal. Previously, the most significant classifications have been based upon the ratio of volatile matter to fixed carbon in the fuel. Parr proposes to use instead a classification on the basis of heat value of pure coal and the percentage of volatile in the pure coal. By this means he gets a classification that is related only to the coal substance and is not dependent upon accidental variations in ash or sulphur in the sample tested.

By his formula it is found that very reliable results are obtained. Different samples from the same seam or mine give close agreement, even though one may be clean and the other sample dirty. Even samples as different as those obtained as pure coal and as tailings from the washing of coal show for the coal constituent of the pure and



GROUPING AS TO VOLATILE

impure fractions identical results. Thus it is evident that the basis of classification is the coal itself and not the impurities carried.

The chart shows a grouping of the coals from the brown lignites to anthracite. Brown lignite, black lignite, subbituminous, and Western bituminous coals differ essentially in the heating value, the ash-, moisture-, and sulphur-free coal substance. But among Western bituminous, Eastern bituminous, semi-bituminous, semi-anthracite, and anthracite groups, the distinction is not heat value of the pure coal, but percentage of volatile matter that this pure coal contains.

It will be noticed that only a few samples of each class fall outside of the territory allotted to them. Professor Parr says that in these few cases there is as much reason to doubt the naming of the samples as there is to doubt the correctness of the chart. In other words, the chart seems to afford a better basis of classification than does the varied judgment of a large number of persons who may be examining the fuel.

These results were favorably received at the Birmingham meeting of the American Chemical Society during the first week in April.

Successful Use of Blast Furnace Gas

Extraordinary results have recently been achieved in the John Cockerill Works at Seraing, Belgium, by the utilization of blast-furnace gas as a source of power. For a period of seven months the whole of the electrical power required, has been produced by gas engines driven by the gas supplied from a single blast furnace. The results certainly tend to prove the reliability of the gas engine to be equal to that of the steam turbine; in fact, the power produced in this manner is more than twice the power possible to obtain from a steam plant using the same amount of gas.

When it has been necessary to stop the furnace for a short while, the time chosen has generally been when the power station might conveniently be closed down, say Sunday. To re-start, the furnace has been blown by a cupola fan, giving sufficient gas to purge the mains up to the gas-cleaning plant. This has then been started and gas delivered at sufficient pressure to allow of the engine running.

Tests show that 35 per cent gas is absorbed by the hot-blast stoves, 10 per cent by the gas-blowing engines, 5 per cent lost, and 50 per cent available for the gas-driven central electrical power station. For a consumption of 200 tons of coke per 24 hours, the load shown at the central station was 4,000 kw., equal to an average load on the gas engines of 77 per cent of their rated capacity.—*The Blast Furnace and Steel Plant.*

Colorado River Development Bills Introduced in Congress

A bill providing for the development of the lower Colorado River was introduced April 26 in the Senate, and a similar measure has been put before the House. The main object is regulation of the river to prevent flood damage; irrigation is made next in importance and power development third. Appropriations up to $70,000,000 are authorized. The bills will probably become the center of considerable discussion. The Senate measure is summarized here, paragraph by paragraph:

The United States reserves to itself the exclusive right to develop the main trunk of the Colorado River below the mouth of Green River.

The Secretary of the Interior is empowered to build a dam and other necessary works so as to make a reservoir at or near Boulder Canyon.

He is empowered also to grant power rights for water made available by the dam and is directed to give preference to applications made by political subdivisions.

He is authorized to make leases of these power rights under terms to be decided by him, but not for more than fifty years.

A political subdivision may, with the Secretary's consent, be given perpetual power rights under terms providing for payment by it, in annual installments over a period not longer than twenty-five years, of an amount bearing the same ratio to the cost of the entire development as its allotment of water bears to all the water available for power generation, together with payment of a like proportion of the total operating expense and of interest at 5 per cent on the unpaid portion of the cost. Title would remain with the United States, but the power right would continue, after the proportionate share of the cost had been paid up, as long as the share of operating expense is paid annually.

Power development along canals built under this Act is to belong to the districts contributing to the construction cost of the canal, in proportion to the contributions, provided that until this construction cost is paid up the Secretary shall control the disposition of power rights and apply the net proceeds to the cost.

In general, the cost of building the dam and all incidental works shall be charged against the lands to be irrigated in proportion to the benefits resulting to them, as determined by the Secretary.

The dam and reservoir shall be used: First, for river regulation and flood control; second, for irrigation; third, for power.

The Act does not affect any rights along the river above the reservoir.

All lands found irrigable by the project shall be withdrawn from public entry until water is available to them, when they shall be opened to entry, giving preference to ex-service men.

Authority is given for the appropriation from time to time of the money required for the development, the total amount to be not more than $70,000,000.

The existing contract between the Government and the Imperial Irrigation District is not affected by the Act, but is to be modified properly by the Secretary and the District.

"Political subdivision," as used in the Act, means any state, district, municipality or other Government organization.

News in the Field of Power

License for Big Creek and Other Hydro Plants

The Federal Power Commission recently approved the granting of a license to the Southern California Edison Co. for its Big Creek No. 3 plant, in Fresno and Madero Counties, California.

An installed capacity of 195,000 hp. is contemplated. No storage is included other than the small capacity of the reservoir formed by the diversion dam, amounting to 937 acre-feet. The entire project lies within the Sierra National Forest. Its estimated cost is $13,000,000.

Another license granted was for the Portland Railway, Light and Power Co., of Portland, Ore., for a license for a power development on the Clackamas River, partly within the Oregon National Forest, Clackamas Co., Ore., involving the use of water from Oak Grove and Three Link Creeks. An installed capacity of 40,000 hp. is contemplated.

The Southern Sierras Power Co., of Riverside, Cal., was granted a license for two power developments in Snow Creek, Riverside Co., Cal. An ultimate installed capacity of 4,200 hp. is contemplated. No storage is involved. The project lies mainly within the Cleveland National Forest.

A preliminary permit was authorized for issue to Frank G. Baum, of San Francisco, Cal., covering two proposed power projects on Little Colorado River, affecting lands within the Navajo Indian Reservation, and planned to develop 15,000 hp.

Six applications for permit or license under the Federal Water Power Act were filed with the Commission during the week ended April 15, 1922, making a total of 300 applications received to that date.

New York Co-operating with A.S.M.E. in Boiler Rules

As noted in *Power* for last week, New York State has made the necessary changes in its boiler-inspection rules to permit the acceptance within the state of boilers manufactured elsewhere, provided they have been inspected and stamped by a certified inspector of the National Board of Boiler and Pressure Vessel Inspectors, whereas previously it had been required that all boilers should have been approved by a New York State inspector. Another recent development with regard to boiler matters was the appointment by Thomas C. Eipper, Industrial Code Referee and Chairman of the Advisory Committee on boilers of the Department of Labor, of three subcommittees on boiler rules with duties that may be outlined as follows:

A general revision committee, whose duties will be to revise the State boiler rules, mainly on the basis of the interpretations made from time to time by the American Society of Mechanical Engineers' boiler code committee, which is this year revising the Boiler Code;

A locomotive boiler rule committee, which will make an examination of the locomotive boiler code recently approved by the A.S.M.E., with a view to its adoption by the state;

A miniature boiler rule committee, which will work along the same lines as the A.S.M.E. committee on a code for miniature boilers, thus being fully prepared to take up consideration of the miniature boiler code when it is completed and approved by the society.

The policy of the state officials in the matter is to keep in close touch with the boiler-code work so as to maintain practically complete uniformity with the society's codes.

Going South with the A.S.M.E.?

The main features of the approaching spring meeting of the American Society of Mechanical Engineers, including the schedule of papers of interest to power plant men, were announced in detail in the April 18 issue of *Power*, page 634. The main meeting, as stated there, will be held in Atlanta, Ga., May 8-11, with headquarters in the Piedmont Hotel, and a preliminary meeting will be held May 5 and 6 at Charlottesville, Va.

The program of this preliminary meeting is now available. First there will be a technical session, starting at 9:30 a.m., Friday, May 5, when a paper on "The Organization of an Engineering Problem" will be given by Charles H. Fish. At 11 o'clock "The Ethics of Engineering" will be discussed by Prof. Christie, of Johns Hopkins University. In the afternoon there will be a symposium on the subject, "How Can the Industries Aid Engineering Education." Dean Kimball will give an address at the evening session. On the next day, May 6, there will be opportunity for automobile tours, inspection of the University and observatory, and visits to the home of Thomas Jefferson and other historic places.

As previously announced in *Power*, the program for the main meeting will include a number of papers of great interest to power engineers, covering such subjects as heat balance, hydroelectric development, unaflow engines, etc. The excursion that is planned for May 13 to the Muscle Shoals development ought to attract a large crowd, in view of the attention that has been given the project throughout the country in the last few months.

The headquarters of the Society are at 29 West 39th St., New York City.

Likely That Government Itself Will Develop Muscle Shoals

Disinterested opinion on Capitol Hill is to the effect that no one of the Muscle Shoals offers will be accepted. It is believed the Government will reopen work on the dam and will complete it, after which leases will be made for the disposal of the power.

A subcommittee of the Committee on Military Affairs of the House has made a formal report to the effect that no offer will be considered that does not conform to certain fundamentals. The first essential is that the property be subject to requisition at any time by the Government for the production of war materials, and that nitrate plant No. 2 be kept in such condition as to be capable of producing nitrates at any time. Another condition, held by the subcommittee to be fundamental, is that a definite contract be entered into for the manufacture and sale to the public of a fixed quantity of mixed fertilizer. A third condition is that any deal must be made for the entire property with the exception of the steam plant at Gorgas and the transmission lines connecting it with Plant No. 2.

The Military Affairs Committee is discussing the matter in executive session. All offers except that of Henry Ford have been tabled. The Ford offer, at this writing, is being read paragraph by paragraph. The committee expects to make its final report during the first week in May.

Freight Rate Decision Held Back

It has recently been called forcibly to the attention of the Interstate Commerce Commission that the delay in handing down a decision in the rate-reduction case is having a serious bearing on the business situation; doubtless it is also reducing coal demands greatly. Regardless of the pressure that is being exerted, however, the importance of the case is such that the individual commissioners are being very careful of their ground. They realize that this decision will be the financial yard-stick of the railroads for a considerable time to come. For that reason the chances seem to favor the lapse of some further time before the announcement of a decision.

Refrigeration Summer Course

A three months' intensive course in refrigeration engineering is being started May 2 by the Siebel Institute of Technology's Refrigeration Engineering Division, 960-970 Montana St., Chicago. This summer course has been decided upon to meet the needs of those who were unable to take advantage of the Institute's first course.

Obituary

William C. Tucker, prominent in Newark No. 3, New Jersey, of the National Association of Stationary Engineers, died recently at his home in Newark. He was born in Middlefield, N. Y., seventy years ago and came to Newark before the age of 20. A few years later he went to work for Enos Richardson & Co., and at the time of his death he was chief engineer of the Richardson Building.

Personals

A. V. Hutchinson, formerly with the trade papers, *Sheet Metal Worker* and *Sanitary and Heating Engineering*, has been appointed manager of publications for the American Society of Heating and Ventilating Engineers.

J. C. Baker has left the headquarters office of the American Society of Heating and Ventilating Engineers, where he was assistant secretary of the society, to rejoin the engineering staff of the American Blower Co., of Detroit.

W. I. Whitefield, formerly assistant superintendent of the lighting and power department of the Roanoke (Va.) Railway and Electric Co., has become associated with the Charles M. Kelso Co., engineers and contractors, of Utica, N. Y.

Pierce J. Kent was recently tendered an elaborate reception and dinner by about 200 Edison men to commemorate his thirty-fifth anniversary of service with the Boston Edison organization. He is now chief system operator. At the dinner he was presented with an attractive group of electrical home appliances.

John H. Mullen, well known in N.A.S.E. circles, particularly in New England, and a regular attendant at the National conventions of that body, may be found until further notice at Los Angeles, Cal. He will be missed when the Yankee Engineers gather, but will probably soon become one of the vitreous fruit delegations to the National convention.

H. S. Killelea, for the last three years superintendent of electrical construction with the New England Power Co., has gone into business for himself in Brattleboro, Vt., as a consulting and electrical engineer, and has also organized a repair and contracting company. He has already taken care of several large hydro-electric construction projects through his Brattleboro office.

J. G. Vincent, who has served as electrical engineer for the Twin City Rapid Transit Co. for eighteen years, has been appointed by the Minneapolis City Council to co-operate with the "high dam" engineer of the City of St. Paul in working out plans for developing power at the Government dam in the Mississippi River between Minneapolis and St. Paul, so that the best interests of the two cities may be served in case the Federal Government decides to lease the dam to them.

Society Affairs

Coming Conventions

American Society of Mechanical Engineers, 29 West 39th St., New York City. Spring meeting at Atlanta, Ga., May 8-11.

American Water Works Association, 153 West 71st St., New York City. Annual convention at Philadelphia, May 15-19.

National Electric Light Association, 29 West 39th St., New York City. Annual convention at Atlantic City, N. J., May 15-20.

American Order of Steam Engineers; Andrew Lauterbach, 4726 North Warnock St., Philadelphia, Pa. Annual convention and exhibition at Philadelphia, June 5-9.

National District Heating Association; D. L. Gaskill, Greenville, Ohio. Annual convention at Cedar Point, Ohio, June 20-23.

American Society for Testing Materials, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, N. J., June 26-July 1.

Canadian Association of Stationary Engineers; G. C. Keith, 51 Wellington St. West, Toronto, Ont. Annual convention and exhibition at Kitchener, Ontario, June 27-29.

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual conventions and exhibitions of the State Associations scheduled as follows:

New Jersey, at Elizabeth, June 2-4; E. J. Flynn, 423 Newpoint Road, Elizabeth N. J.

Illinois, at Chicago, June 7-10; I. S. Pieters, 1130 Clay St., Chicago.

New York, at New York City, June 8-10; T. J. Condon, 102 Seventh Ave., New York City.

Indiana, at Anderson, June 9-10; Frederick L. Ray, Anderson, Ind.

New England, at Springfield, Mass., July 12-14; James Morgan, 53 Devonshire St., Boston.

Michigan, at Kalamazoo, July 19-21; A. M. Adams, 1307 Stockbridge Ave., Kalamazoo, Mich.

The Heating and Piping Contractors National Association will hold its annual convention in Buffalo, May 31-June 3.

The Engineers' Society of Milwaukee has moved its secretary's office to 548 Milwaukee St., the telephones, however, remaining the same.

The Association of Iron and Steel Electrical Engineers plans to hold its annual convention Sept. 11-16 in Cleveland, Ohio. The new Cleveland Public Hall is expected to afford unusually good facilities for the exhibition that will be a feature of the convention.

Providence Section, A.S.M.E., will have a chance to see the Sanford Riley motion picture of an underfeed stoker in operation in the Society rooms at 8 p.m., May 12. F. H. Daniels, general manager of the Sanford Riley Stoker Co., will take as the title of his lecture, "Photographing the Business End of an Underfeed Stoker."

The Pennsylvania Electric Association has announced a meeting of its Western Geographic Section at the William Penn Hotel, Pittsburgh, Pa., May 4, including morning and afternoon sessions. Prominent central-station men will speak on: "Pertinent Points in Rate Revisions," "The Importance of Safe Practice," "Water Power and Water Power Legislation," "Consumers' Records and Billing Methods," "Fixed Capital Records," "Job Specification Application to Training Personnel."

Business Items

The Pennsylvania Pump and Compressor Co., of Easton, Pa., has opened a Chicago office under the management of H. M. Montgomery, at 105 West Monroe St.

The Patterson-Kelley Co., after nearly a quarter of a century at 26 Cortlandt St., New York City, moved on May 1 to its new quarters in the Architects' Building, at 101 Park Ave.

The Heine Boiler Co. is the new name just announced by the Heine Safety Boiler Co. of St. Louis, Mo. It is felt that the word "Safety," which was applied to the first Heine boiler because it was a water-tube, has become superfluous in the forty years since it was first adopted.

W. H. Campbell, Inc., 30 Church St., New York City, is a new business recently formed for the sale of new and used chemical, refrigeration and power apparatus by W. H. Campbell, who has been general sales manager for the last two years of the Charleston Industrial Corporation at Nitro, W. Va.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	April 17, 1922	April 24, 1922
Pool 1,	New York	$3.40	$3.50@3.75
Pocahontas,	Columbus	1.90	1.90@2.10
Clearfield,	Boston	2.15	2.50@2.90
Somerset,	Boston	2.25	2.40@3.00
Pittsburgh,	Pittsburgh	....	.....
Kanawha,	Columbus	1.60	2.00@2.25
Hocking,	Columbus	1.75	2.00@2.25
Pittsburgh No. 8	Cleveland	2.35	2.50@2.60
Franklin, Ill.,	Chicago	2.75	2.50@3.00
Central, Ill.,	Chicago	....	2.50@2.75
Ind. 4th Vein,	Chicago	2.50	2.25@2.75
Standard,	St. Louis	....	.....
West Ky.,	Louisville	2.00	1.90@2.10
Big Seam,	Birmingham	1.70	1.50@1.90
S. E. Ky.,	Louisville	1.75	2.25@2.50

New York—Apr. 26, Port Arthur light oil 22@25 deg. Baumé 3¼c. per gal.; 30@35 deg., 4⅜c. per gal., f.ob. Bayonne, N. J.

Chicago—Apr. 5, for 24@28 deg. Baumé, 85@90c. per bbl.; 21@36 deg., 2⅜@2½c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—Apr. 25, f.o.b. refinery Pennsylvania, 36@40 deg. 4⅜c. Kentucky fuel oil, 26@30 deg., 3c. per gal. Western, 24@30 deg., 85c. per bbl.; 32@34 deg., 3c. 36@38 deg., 3¼c. 38@40 deg., 3½c. per gal.

St. Louis—Mar. 25, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 90c. per bbl.; 26@28 deg., 95c.; 28@30 deg., $1.10; 32@34 deg. 2¾c. per gal.

Philadelphia—Apr. 24, 26@28 deg. Baumé, Oklahoma, 85@90c. per bbl.; 30@34 deg., Oklahoma (group 3), 2⅞@3c. per gal.; 16@20 deg. Seaboard, $1.05@$1.15 per bbl.

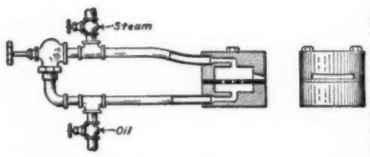
Cincinnati—Apr. 18, for 26@30 deg. Baumé, 4¼.; Diesel 32@36 deg., 4½c. per gal.; distillate 38@48 deg., 5½c. per gal.

Cleveland—Apr. 18, 26@30 deg Baumé, 3¼c. per gal.

Condensed-Clipping Index of Equipment

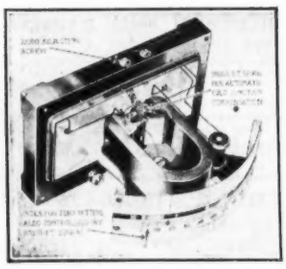
Patented Aug. 20, 1918

Burner, Oil "Power," 1922.
Ideal Oil Burner Co., Inc., Port Arthur, Tex.



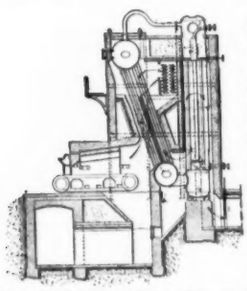
A simple oil burner, having but three parts: The top casing, containing the steam chamber; the bottom casing, containing the oil chamber; and the vaporizing plate, separating these two chambers and making the steam chamber serve as well as a mixing chamber. It has been designed with a view to preventing excessive carbonization. Its simplicity of construction allows it to be easily and quickly removed from the line, cleaned and reinstalled. Further described on page 66 of "Power" for Jan. 10, 1922.

Pyrometer, Brown Cold-Junction Compensated "Power," 1922.
Brown Instrument Co., Philadelphia, Penn.



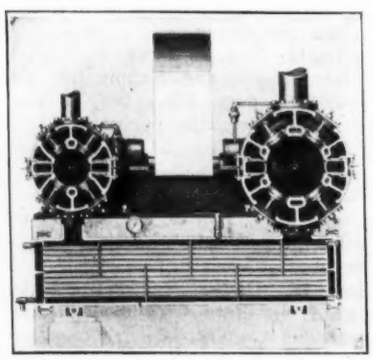
A thermo-electric pyrometer, which is automatically compensated in the instrument for changes in cold junction temperatures, and which includes means of setting the pointer of the instrument to zero in the usual manner. In compensating for cold junction changes in temperature, it is only necessary to bring the compensating or extension leads from the thermocouple to the instrument. Any number of thermocouples with their extensions or compensating leads can be brought to the one instrument having this automatic compensation. Recording instruments also can be equipped in this way. Described in "Power," Dec. 27, 1921.

Boiler, Water Tube "Power," 1922.
A. L. Brueggerman, Newark, N. J.



The feature of this boiler is a water-storage reservoir that is connected with the drums of the boiler itself. The upper part of this reservoir is used as a steam dome. The circulating water passes through the main chamber of the reservoir, and the gases from the furnace pass up around the outside of the reservoir, which is a vertical cylinder shown at the right in the illustration. It is divided into three sections by two tube plates near the top and bottom, with tubes between. The feed-water inlet is in the steam dome, shown at the upper right-hand corner; the water passes down through the reservoir into the lower drum of the boiler proper and up through the inclined bank of tubes into the upper drum. Gases from the furnace pass up along the front half of the bank of tubes, down along the rear half, up around the reservoir ,and down and out into the stack. Described further on page 492 of "Power" for Sept. 27, 1921.

Compressor, Air, New Type Belt Driven "Power," 1922.
Ingersoll-Rand Co., 11 Broadway, New York, N. Y.

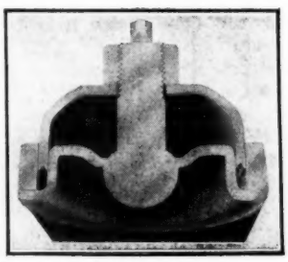


The unit is supplied with plate valves for both air intake and discharge, and is also equipped with a five-step clearance for regulating the compressor outfit. The compressor is automatically loaded or unloaded by the reduction or addition of clearance space to the air cylinders. The unit is also equipped with a maximum demand stop, which will prevent the compressor from being operated at any higher maximum load than is desired. Described on page 23 of "Power" for Jan. 3, 1922.

Alarm, Hot Bearing "Power," 1922.
J. H. Fedeler, 11 West 40th St., New York City.

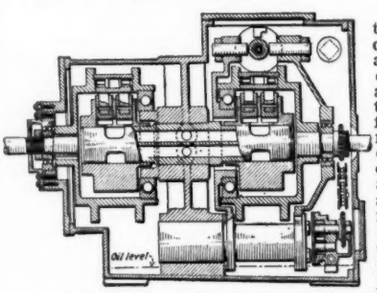
This hot bearing alarm consists of a glass oil cup filled with a strong-smelling lubricating oil. The end of the spout is provided with a sulphur plug that prevents the oil from running out of the cup. This fusible plug can be provided to melt at a predetermined temperature of from 150 to 300 deg. F. or more. If the bearing becomes too hot, the fusible plug melts and the odor of the oil calls attention to the trouble. Another alarm consists of a strip of spring steel that is rolled and held in that position by a rivet of soft metal that melts at 190 deg. or more, as the case may require. The roll is screwed to the outside of a bearing, and as the inside is painted with luminous paint, if the bearing heats enough to melt the rivet, the roll unrolls and the luminous paint shows in the dark. Described more fully in "Power" for Dec. 27, 1921, page 1008.

Handhole Plate "Power," 1922.
Key Boiler Equipment Co., East St. Louis, Ill.



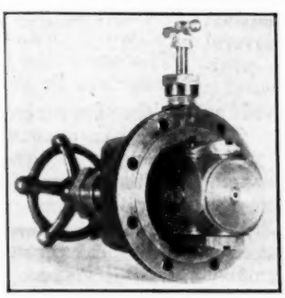
A new design of handhole plate suitable for all equipment requiring plates or screw plugs. The makers claim that it can be detached in about 20 sec. and reinstalled in about 25 sec. To install the plate, the handhole is tapered 3 deg. large on the outside. The inner part of the device, the so-called closure plate, has a taper of about 10 deg. Between these two tapers is wedged the closure ring, which locks the device in position and squeezes the packing so as to make a tight joint. Further described in "Power" for Jan. 3, 1922, page 18.

Variable-Speed Power Transmission System "Power," 1922.
Oil Gear Co., Milwaukee, Wis.



This speed-control system consists essentially of a pump that can be adjusted to a wide range of delivery capacities, and a motor driven by the working fluid received from the pump. The drive receives power from a constant-speed lineshaft or constant-speed motor, and delivers this power at any required speed from zero to a maximum in either direction at an efficiency, at full load, of 85 per cent. The system lends itself readily to various methods of remote and pilot control; for instance, coal conveyors, coal pulverizers and stokers. It may be arranged so that pressure controls the speed. Described more fully in "Power" for Dec. 27, 1921, page 1018.

Valve, Multiple Disc "Power," 1922.
Fisher Compounded Valve Co., Providence, R. I.



A globe valve having four discs, any one of which may be brought into position for obtaining a new seating contact without taking the valve apart. Each of the four faces of the cube that takes the place of the usual disc, as shown in the illustration, has a seating surface of a different diameter; in the case of the 1¼-in. valve, the four diameters are 1⅝, 1⅞, 2 1/16 and 2⅛ in. respectively. The valve seat itself is as large as the largest of these, but the face with the smallest diameter is used first, and then, as wear takes place, the next larger face is brought into position in turn, until the four are used up. To change the faces the valve is opened—that is, the cube is withdrawn from the seat—and when the cube is back as far as it will go it is turned around by pressing in and turning the small handle at the top in the illustration. Described further on page 57 of "Power" for Jan. 10, 1922.

Clip, paste on 3 x 5-in. cards and file as desired

New Plant Construction

PROPOSED WORK

Ark., Little Rock—The Machinery Exchange Co., A. O. U. W. Bldg., is in the market for complete ice plant machinery for 10 ton ice plant also engine and turbo generator 150 to 200 kw. capacity, 3 phase, 60 cycle, 80 per cent power factor exciter and switchboard complete, also turbo generator 5,000 kw. capacity, 3 phase, 60 cycle.

Ark., Texarkana—The Index Sulphur Drainage District of Miller County is having plans prepared for a system of open ditches and levees with pumping plant to reclaim 125,000 acres along the Red River. Morgan Engr. Co., Memphis, Engrs.

Cal., Los Angeles—A. E. Corlett & C. Beelman, Assoc., Archts., 408 Union Bank Bldg., are receiving bids for a 12 story, 106 x 187 ft. store and office building including a steam heating system on 7th and Hope Sts. for I. W. Hellman Estate, Nevada Bank Bldg., San Francisco. About $1,500,000.

Cal., Los Angeles—Dunn-Williams Co., 26 Montgomery St., San Francisco, and H. J. Bauer Co., I. W. Hellman Bldg., Los Angeles, are having plans prepared for a 12 story, 60 x 155 ft. store and office building including a steam heating system on Spring St. About $500,000. A. E. Curtlett & C. Beelman, 408 Union Bank Bldg., Archts.

Cal., Los Angeles—Paden & Price, Story Bldg., are having plans prepared for a 12 story, 58 x 136 ft. bank and office building including a steam heating system on 7th and Spring Sts. A. E. Curlett, 538 Merchants Natl. Bank Bldg., Archt.

Cal., Redwood City—The County of San Mateo received bids for steam boiler plant, refrigeration, steam heating and ventilation, etc., for hospital from J. F. McGowan, 150 A St., $27,562; Knittle-Cashel Co., 224 5th St., San Francisco, $29,887; and Lawson and Drucker, 450 Hayes St., San Francisco, $32,319.

Cal., San Leandro—The Bd. Supervisors will receive bids until May 15 for two 1 story power house and laundry buildings at the County Infirmary. About $60,000. H. H. Meyers, Kohl Bldg., San Francisco, Archt. Noted Dec. 18.

Cal., San Francisco—The Pacific Gas & Electric Co., 445 Sutter St., plans to build an office building on Market and Beale Sts. About $1,250,000. Architect not selected.

Cal., San Leandro—The county of Alameda, Oakland, is receiving bids for two 1 story laundry and power house buildings at the County Infirmary site. About $60,000. H. H. Meyers, Kohl Bldg., San Francisco, Archt.

Cal., Yuba City—The Pacific Gas & Electric Co., 445 Sutter St., San Francisco, is having plans prepared for a sub-station on O'Banion Corners. About $70,000. Private plans.

Conn., Stamford—The Bd. Educ., plans to build a 3 story high school. About $800,000. Architect not selected.

D. C., Washington—A. E. Walker Investment Co., 813 15th St., N. W., plans to build an 8 and 11 story, 140 x 153 x 455 ft. hotel on Connecticut Ave. and De Sales St. About $6,200,000. R. F. Beresford, Ambassador Apts., Archt.

Fla., Pablo Beach—The Bd. Trustees, C. H. Mann, Chmn., will receive bids until May 5 for a direct connected internal combustion engine, generator, etc., also a 22,000 volt transmission line from here to South Jacksonville including two sub-stations.

Ga., Savannah—The Georgia Ice Co., 431 Harmon St., A. M. Dixon, Pres., is in the market for a 300 hp. Heine water tube boiler; a 250 hp. Casey Hedges water tube boiler and two 72 in. x 18 ft. H. R. T. boilers, 150 hp. each.

Ia., Mason City—The city, J. H. McEwen, Clk. plans to install new compressor, condenser and heater for power plant. About $25,000. L. P. Wolff, 1001 Guardian Life Bldg. St. Paul, Engr.

Ill., Chicago—A. S. Ahlschuler, Archt., 28 East Jackson Blvd., will soon receive bids for four 3 story, apartment buildings including a steam heating system on Ingleside Ave. and 54th Place, for S. D. Jonas and J. M. Kahn. About $600,000.

Ill., Chicago—W. P. Doerr, Archt., 28 East Jackson Blvd., is receiving bids for a 7 story, 50 x 170 ft. apartment including a steam heating system on South Shore Drive near 54th St. for E. Doerr. About $500,000.

Ill., Chicago—Plotke & Grosby, 2532 North Clark St., are having plans prepared for a 5 story 150 x 210 ft. theatre, store, hotel and dance hall including a steam heating system on Lawrence and Winthrop Aves. About $1,500,000. J. E. O. Pridmore, 38 South Dearborn St., Archt.

Ill., Rockford—The Rockford Children's Home Society, 623 North Main St., B. W. Maguire, Chn. Building Committee, plans to build a 5 story orphanage including a steam heating system. About $400,000. Architect not selected.

Ind., Kendallville—Cahill & Douglas, Engrs., 217 West Water St., Milwaukee, is receiving bids for two 300 hp. boilers for the McGray Refrigerator Co.

Kan., Utica—The city is having plans prepared for a pumping plant, testing wells, a 1 story, 20 x 40 ft. pump house and 50,000 gal. steel tank on 80 ft. tower. About $15,000. Ruckel Engr. Co., Interurban Bldg., Hutchison, Engrs.

La., New Orleans—The U. S. Engineer Office, Room 329 Custom House, will receive bids until May 11 for turbo generator, motor, switchboard, controllers, etc., and condensor for the U. S. pipe line dredge "Gulfport."

Mich., Detroit—The Auto Collapsible Rim Co., Inc., c/o P. E. Rossello, Archt., 406 Congress Bldg., plans to build an 8 story, 110 x 166 ft. auto rim factory including a steam heating plant on Bellevue Ave. About $500,000.

Minn., Detroit—The city, E. J. Bestick, Clk., plans to enlarge power plant. About $40,000. L. P. Wolff, 1001 Guardian Life Bldg., St. Paul, Engr.

Mich., Detroit—S. Feldman, 1206 Penobscott Bldg., plans to build an 8 story, 150 x 170 ft. apartment hotel including a vapor steam heating plant on Charlotte St. About $1,000,000. J. G. Jogerst, 55 Rowland Bldg., Archt. Washed air ventilating equipment, and refrigeration machinery will be installed.

Mich., Detroit—J. F. Lamb Co., 1938 Franklin St., is in the market for miscellaneous machine shop equipment including motors ⅛ to ¾ hp., 110 volt, 60 cycle, single phase.

Mich., Detroit—The Park Boulevard Co., c/o A. Kahn, Archt., 1000 Marquette Bldg., plans to build an 8 story, 80 x 100 ft. store and office building including steam heating equipment, two pipe gravity return, on Adams Ave. and Park Blvd. Exhaust fans, motors, etc., will be installed.

Mich., Saulte Ste. Marie—The Cadillac Lumber & Chemical Co., Cadillac, is having plans prepared for a 2 story, 95 x 280 ft. and a 100 x 114 ft. saw mill to include a 32 x 40 ft. engine room, a steam power plant will be considered later. About $200,000. E. C. Hall, 221 Grand Ave., Milwaukee, Engr.

Neb., Lincoln—The University of Nebraska, L. F. Seaton, Purch. Agt., plans to install oil burners in heating plant to replace present equipment now heating 5 large boilers and 3 small boilers, generating about 5,000 hp.

N. Y., Binghamton—The Binghamton Gas Wks. plans an addition to generator plant on Court St. About $8,000. Is open for quotation on gas generator and other machinery.

N. Y., Buffalo—The Buffalo City Hospital, 462 Grider St., will receive bids until May 8 for the installation of water filtration and softening equipment including motor and turbine driven service pumps.

N. Y., Geneva—The Bd. Educ. plans to build a high school. Cost between $400,000 and $500,000. Architect not announced.

N. Y., Hoffman Island—Treasury Dept., J. A. Wetmore, Supervising Archt., Wash., D. C., will receive bids until May 8 for alteration and addition to boiler house, also separate bids for mechanical equipment, including fire lines, steam and water connections to laundry machinery and transformer sub-station at the U. S. Quarantine Station, here.

N. Y., New York—Hospital for Joint Diseases, 124th St. and Madison Ave., will soon receive bids for an 8 story addition to hospital. Burhman & Kahn, 56 West 45th St., Archts.

N. Y., Olean—The city plans installation of a boiler in heating plant at school No. 4 of sufficient capacity to take care of 2 story 16 room addition.

N. Y., Onondaga Valley—The Onondaga Valley Academy Trustees, will receive bids until May 8 for heating and ventilating system. About $10,000. M. L. King, 601 Snow Bldg., Syracuse, Archt.

N. Y., Utica—The Walmer Realty Co. of Syracuse has purchased a site on Lafayette and Seneca Sts. and plans to build a 10 story office building. About $1,400,000. Address A. B. Merrill, 428 Greenwood Place, Syracuse.

N. C., Lenoir—A. M. Kisler, Morgantown, plans hydro electric development on Wilsons Creek near here, involving a 17,000 ft. tunnel, etc., about 2700 hp. will be developed. Estimated cost $100,000.

N. C., Pittsboro—The city, B. Nooe, Mayor, is receiving bids for furnishing and erecting 300 k.v.a. out-door sub-station or 150 k.v.a. sub-station, street lighting equipment, pole line materials, etc. W. M. Piatt, Durham, Engr.

N. C., Wilmington—The Hotel Corp. plans to build a hotel on 2nd and Chestnut Sts. About $700,000. R. Moore, 125 Princess St., Pres.

N. D. Velva—The Velva Coal Products Co., J. W. Bliss, Mgr., is having plans prepared for lignite mining project will probably include an electric generating plant. About $500,000. Dakota Engr. & Constr. Co., Valley City, Engrs.

O., Cincinnati—The Consolidated Equipment Co., Commercial Tribune Bldg., R. C. Johnson, Jr., Purch. Agt., is in the market for complete power plant equipment with 300 hp. Crude oil engines, generator and motors, d.c., 220 volts.

O., Cincinnati—L. P. Hazen & Associates, Court House, plans to build a 12 story, 100 x 140 ft. garage on 8th St. About $1,000,000. Architect not selected.

O., Cleveland—The Bd. Educ., Rockwell Ave. and 6th St., F. J. Hogan, Director, is in the market for a boiler feed pump for West High School building.

O., Cleveland—Walker & Weeks, Archts., 1900 Euclid Ave., will soon award the contract for a 4 story, 50 x 200 ft. store and office building on 4th St. and Euclid Ave. for the S. S. Kresge Co., (5 and 10 cent stores), Detroit. About $300,000.

O., Columbus—The city received bids for a dam and appurtenances across the Scioto River, from the Columbus Constr. Co., Central Bldg., Columbus, $1,001,616.42; Thompson-Starrett Co., 79 Wall St., New York City, $1,115,119; J. F. Casey Co., Union Ave., Pittsburgh, Pa., $1,173,256. Noted Jan. 31.

O., Columbus—The State Dept. of Welfare, Oak and 9th Sts., will receive bids until about May 26 for boilers, stokers, engine and generator unit including one 350 hp. boiler and one 125 k.w. generator for the Institution for Feeble Minded at Orient. Estimated cost, $24,000; boilers and stokers including two 350 hp. boilers and smoke stack for the Ohio State Reformatory at Mansfield. Estimated cost, $40,000; boilers, stokers, engine and generating unit including two 250 hp. boilers, also coal crusher and conveyor for the Cleveland State Hospital, Cleveland. Estimated cost, $33,500; boilers and stokers including four 250 hp. boilers for the Ohio Soldiers' and Sailors' Home, Sandusky. Estimated cost, $40,000; boilers, stokers, new wells and equipment including

two 350 hp. boilers and pumping equipment for waterworks system for Toledo State Hospital, Toledo. Estimated cost, $40,000; generating unit including 400 k.w. generator at the Ohio Penitentiary, Columbus. Estimated cost, $25,000; steam engine to be installed on old base for the Ohio Hospital for Epileptics, Gallapolis. Estimated cost, $5,000; ice manufacturing machine, 10 ton capacity for the Ohio Sanitarium, Mt. Vernon. Estimated cost, $6,500; steam driven air compressor for Massillon State Hospital, Massillon. Estimated cost, $6,000.

Pa., Ardmore—The School Bd. of Radnor Twp., c/o W. J. Byrne, plans to build a 3 story junior high school. About $400,000. Savery & Scheetz, St. Girard Bldg., Phila., Archts.

Pa., Bryn Mawr—The School Bd. of Radnor Twp., c/o W. J. Byrne, Ardmore, plans to build a 3 story high school. About $300,000. Ralph & White, Penna. Bldg., Phila., Archts.

Pa., Chambersburg—A. C. Wood, Engr., Stock Exchange Bldg., Phila., is receiving bids for a 1 story, 80 x 95 ft. power house on 3rd St. for the Borough of Chambersburg.

Pa., Phila.—The Dept. of Public Wks., City Hall, F. Caven, Room 216, Purch. Agt., is in the market for two horizontal crank and flywheel double acting air compressors, 12 in. diameter cylinders. 10 in. stroke, 250 lb. per min.

Pa., Phila.—H. Trumbauer, Archt., Land Title Bldg., is receiving bids for an 18 story, 53 x 235 ft. office building on Juniper and Walnut Sts., for L. Cohan, c/o Middle City Realty Co., Phila.

Pa., Pittsburgh—The Philadelphia Co., 6th Ave., is having plans prepared for a 9 story, 83 x 240 ft. service and office building. About $1,000,000. Private plans.

Pa., Pittsburgh—The St. Louis Independent Packing Co., 6349 Station St., will soon award the contract for a 2 story, 106 x 109 ft. cooler building on Hamilton Ave. Private plans.

Pa., Titusville—The Titusville Light & Power Co. plans the construction of 23,000 volt high tension transmission line from Oil City to Titusville about 17 mi.

Pa., West Chester—Hoopes Bros. & Thompson are in the market for an electric air pump and compressor.

Tex., Childress—The city, J. W. Mitchell, Mayor, voted $310,000 bonds for waterworks improvements to include a dam across the H.-K. Canyon, constructing 9 mi. of pipe line and the installation of a pumping plant including machinery. R. G. Carraway Co., City Engrs.

Tex., Karnes City—Terrill Bartlett, Engrs., Calcasien Bldg., San Antonio, will receive bids about June 1 for waterworks system including pump house, engines, etc. About $65,000.

Tex., Robstown—The Nueces County Water Improvement Dist. No. 3, will receive bids until May 4 for pumping plant, electrical equipment, water supply and purification plant, canals, etc. Pumping plant to deliver 18,000 to 20,000 gal. per min. Alternate proposals to deliver 14000 to 15000 gal. per min.

Va., South Norfolk—The city received bids for a sanitary sewerage system; electrical automatic equipment for pumping unit; erection of pumping building and collecting well; discharge line and 11⅞ mi., 8 to 20 in. pipe sewer from Ocie Dashiell & Son, 507 South St., Portsmouth, $132,-112.35; Robertson-Benney Co., Norfolk, $132,974.90; Brune Pizzimento & Co., Hayettsville, Md., $169,610.50. Noted April 18.

W. Va., Bellaire—The Bd. Public Service G. T. Kreglow, Director, City Bldg., will receive bids until May 8 for furnishing one steam or electric driven centrifugal pump having a capacity of $6,000,000 gal. per 24 hrs. against a head of 100 lb. pressure, also a steam electric driven vertical type centrifugal pump capacity 6,000,000 gal. per 24 hrs. against a head of 50 ft.

Wis., Madison—L. Cohn, 756 West Washington Ave., is receiving bids for a boiler and steam heating plant for store and office building. About $25,000. M. P. Schneider, 401 West Doty St., Engr.

Wis., Madison—The Madison Gas & Electric Co., 120 East Main St., is receiving bids for a 1 story, 50 x 65 ft. power house on Main St. About $50,000. Mead & Seastone, State Journal Blk., Engrs. Coal bunker and coal handling machinery will be installed.

Wis., Milwaukee—Comr. of Public Wks. will receive bids until May 4 for the foundation, excavation and drainage for Riverside pumping station at foot of Chambers St. About $1,500,000 complete. Judell & Bogner, 445 Milwaukee St., Archts. G. Staal, City Hall, Engr.

Wis., Milwaukee—The M. Hilty Lumber Co., Foot of 12th St., is having plans prepared for steam power plant including the installation of boilers, engines, feed water heater, etc., on 37th St. Cahill & Douglas, 217 West Water St., Engrs.

Wis., River Falls—The Bd. of Normal School Regents, W. F. Kettle, Secy., Madison, will receive bids until May 5 for a 1 story, 50 x 95 ft. power and heating plant at the State Normal School here. About $150,000. A. Peabody, State Capitol, Madison, Archt. Power and heating plant machinery will be installed.

Wis., Stevens Point—The city, W. T. Bronson, Clk., is having plans prepared for additional pumping equipment and machinery for water suppply. W. G. Kirchoffer, Vroman Blk., Madison, Engr.

Wis., Verona—A. D. Conover, Archt., Tenney Blk., Madison, will receive bids until May 10 for a power house including equipment for Dane County. About $40,-000. Noted Jan. 17.

Wis., Whitewater—The Bd. of Normal School Regents, W. J. Kettle, Secy., Madison, will receive bids until May 5 for a 1 story, 50 x 85 ft. power and heating plant at the State Normal School here. About $100,000. A. Peabody, Capitol Bldg., Madison, Archt. Power and heating plant equipment and machinery will be installed.

Wyo., Casper—The Bd. Educ. plans to build a junior high school here. About $500,000. Architect not announced.

Ont., Forest—The council is having plans prepared for a pump house, mains and fire protection system. About $35,000. F. A. Dallyn, Provincial Health Dept., Toronto, Engr. Prices wanted on pumping equipment, mains, etc.

Ont., Seaforth—The town will receive bids until May 6 for one motor driven electric fire pump, 1,000 gal. per min. capacity; one gasoline driven fire pump 1,000 gal. per min. and two deep well pumps electric. James, Proctor & Redfern, 36 Toronto St., Toronto, Engrs. Noted March 28.

Ont., Toronto—R. Reford Co., Ltd., 20 Hospital St., Montreal, Que., is having plans prepared for a 10 story 53 x 100 ft. office building including a steam vacuum heating system on Bay St. About $500,000. A. R. Denison, Confederation Life Bldg., Archt.

Ont., Trenton—The Dominion Combing Mills, Ltd., A. E. Rea, 709 Continental Life Bldg., Toronto, plans to build a wool combing and washing plant. About $200,000. B. H. Prack, 50 Bay St., Toronto, Archt.

Ont., Woodstock—A. Hastings & Son, Dundas and Berch Sts., plans to install seven oil and gas pumps operated by electric vacuum system.

CONTRACTS AWARDED

Cal., Sacramento—The Modern Laundry Co., c/o C. C. Cuff, Archt., 226 Forum Bldg., will build extensions and alterations to laundry, steam power plant, electric generator system, etc., on 3rd and X Sts. Work will be done by day labor.

Conn., New Haven—A. H. Powell, 177 Church St., has awarded the contract for a 12 story, 64 x 90 ft. office building on Church and Court Sts. to C. W. Murdock, Inc., 505 Grand Ave. About $750,000. A steam heating system will be installed.

D. C., Washington—The Chapin Sacks Co., 1st and M Sts., N. E., has awarded the contract for the construction of an office building and ice plant to F. L. Wagner, 1413 H St., N. W., $75,000.

Ill., Chicago—W. W. Ahlschlager, Archt., 65 East Huron St., has awarded the contract for a 10 story, 137 x 150 ft. addition to hotel Sovereign on Kenmore and Granville Aves. to the B. W. Constr. Co., 10 South La Salle St. About $1,500,000. A steam heating system will be installed.

Ill., Chicago—Rubin & Marks, c/o Loewenberg & Loewenberg, Archts., 111 West Monroe St., has awarded the contract for a 6 story, 127 x 141 ft. hotel on Howard and Bosworth Aves. to Rosenthal & Cornell Co., 80 East Jackson Blvd. About $800,000. A steam heating system will be installed.

Ia., Muscatine—The Muscatine Packing Co., G. B. Stapp, has awarded the contract for a 5 story, 100 x 200 ft. cold storage building; a 5 story, 50 x 100 ft. packing building; 5 story 70 x 85 ft. abattoir and a 1 story, 50 x 100 ft. power house to the Federation Constr. Co., 242 Davidson Bldg., Sioux City, Ia., $200,000.

Mass., Boston—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., has awarded the contract for coal handling equipment at the Navy Yard here to A. Pope, 4722 15th St. N. W., Wash., D. C., $40,200. Noted April 25.

Mich., Grand Beach—C. H. Fuller Co., 629 South Wabash Ave., Chicago, Ill., has awarded the contract for a 3 story hotel (Golfmore) to Rowley Bros., 332 South LaSalle St. About $400,000. A steam heating system will be installed.

N. J., Camden—The Campbell Soup Co., has awarded the contract for a 1 story, 55 x 75 ft. power house to the Engineers, W. Steele & Sons, 16th and Arch Sts., Phila.

N. Y., Bolton—The Sagamore Hotel has awarded the contract for a hotel here to E. V. R. Stires, 17 East 95th St., New York City. About $300,000.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York City, has awarded the contract for a high school (Thomas Jefferson) on Dumont Ave., from Sheffield to Pennsylvania Aves. to G. Colon Co., 81 East 125th St., $1,266,621.

N. Y., New York—W. Crawford, 7 East 42nd St., will build a 12 story apartment at 800 5th Ave. About $600,000. J. E. R. Carpenter, 598 Madison Ave., Archt. and Engr.

N. Y., New York—The Iceland Co., c/o C. B. Comstock, Archt. and Engr., 110 West 40th St., has awarded the contract for a 3 story, 200 x 225 ft. ice skating rink at 242 West 33rd St. to the Turner Constr. Co., 244 Madison Ave. About $200,000.

N. Y., New York—The Webster Apartments, c/o Parish & Schroeder, Archts., 278 Madison Ave., has awarded the contract for a 13 story, 100 x 120 ft. apartment at 413 West 34th St. to Edward Corning Co., 145 East 45th St. About $750,000. A steam heating system will be installed.

N. Y., New York—The 125 East 63rd St. Corp., c/o Sugarman & Hess, Archts., 16 East 43rd St. will build a 9 story apartment at 125-35 East 63rd St. About $350,000. Owner will build by day labor.

N. Y., St. George, S. I.—The Snug Harbor Realty Co., c/o E. Roth, Archt., 119 West 40th St., will build an apartment on Stuyvesant Pl. About $350,000. Owner will build by day labor. A steam heating system will be installed.

N. C. Lexington—The city has awarded the contract for the construction of waterworks plant to Tucker & Laxton Co., Realty Bldg., Charlotte, $96,000. (Pumps and pipe line not included). Noted March 28.

N. C., Raleigh—The city has awarded the contract for the construction of 250,-000,000 gal. impounding reservoir, dam, etc., to the Virginia Machinery & Well Co., 1319 East Main St., $64,381. Noted Dec. 13.

Pa., Norristown—The U. G. I. Co., Broad and Arch Sts., Phila., will build a 2 story, 100 x 200 ft. electric power house here.

Pa., Phila.—The Kensington Ice Co., has awarded the contract for a 2 story, 65 x 112 ft. ice manufacturing plant on Lackawana and Church Sts. to G. Kessler Constr. Co., Drexel Bldg., $15,000.

Va., Richmond—Miller & Rhodes, Inc., 6th St., have awarded the contract for a department store to J. F. Wilson, Mutual Bldg. About $1,000,000. Noted March 14.

Wash., Seattle—The Municipal Water Dept. has awarded the contract for the construction of 16 mi. pipe line from Swan Lake to Volunteer Park, part of municipal water system extensions known as Pipe Line No. 1 to the Grant, Smith & Co., Seattle, $1,468,602.50.

Wis., Peshtigo—The Oconto Service Co., F. Pamferer, Pres., has awarded the contract for a dam and the installation of one additional unit to power plant to C. H. Danielson, Peshtigo. Noted March 21.

Ont., Niagara Falls—The Hydro Electric System, A. Teckoe, Mgr., 120 Welland Ave., has awarded the contract for a 2 story, 45 x 110 ft. transformer station on South and Victoria Aves. to the Robertson Constr. Co., Erie Ave. About $125,000. Noted April 11.

Ont., Seaforth—The council has awarded the contract for a concrete reservoir with capacity of 150,000 gal., and pump house to the B. & N. Milling Co., Milverton; steel tank to the Hunter Bridge Co., Kincardine. Total cost about $30,000. Noted March 28.